RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA

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PREFACE.

THE first Review of the Mineral Production of India, published by the Geological Survey, appeared in Part I of Volume XXXIII of the Records. In preparing it, the Director, Sir Thomas Holland, designed the general plan of the work and surveyed the progress made during the preceding six years (1898-1903). Subsequent issues, covering the periods 1904-1908, 1909-1913 and 1914-1918, followed the same general scheme, but were purposely made more descriptive. The reason for this in the earlier reviews was the fact that Ball's Manual on Economic Geology had long been out of print. Mr. LaTouche's Bibliography of Indian Geology and Physical Geography, with its Annotated Index of Minerals of Economic Value, published within the last eight years, has taken the place of Ball's Manual, and the descriptive parts of the Quinquennial Review might therefore be now thought unnecessary. It is considered, however, that the descriptive matter, provided it is kept within bounds, makes a more connected narrative and ensures a truer interpretation of mere statistics.

The present review, instead of being reduced, has, in fact, been slightly expanded, and, for the sake of ready reference, includes matter which has been published before. It is the fifth of the series, and has been prepared on the same lines as the last by the collaboration of the senior officers of the Geological Survey, who have individually revised the sections committed to their charge. The name of the officer responsible for the revision of each section is shown in the text. The general plan has been retained, and in many cases the descriptive parts have also remained much the same as they were when originally written. Recent additions to our information have, of course, been inserted and figures and statistics brought up to date.

E. H. PASCOE.

The 27th February 1925.

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QUINQUENNIAL REVIEW OF THE MINERAL PRODUCTION OF INDIA FOR THE YEARS 1919 TO 1923. *By the Director and Senior Officers of the Geological Survey of India.*

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INTRODUCTION.

[E. H. PASCOE.]

In the first Review it was explained that although many valuable mineral products were being worked in different parts of the country it was impossible to obtain figures relating to some of them sufficiently precise to be of any value for statistical purposes. The most conspicuous of these "minerals"—classified as such for convenience' sake -are the various forms of building material and slate, which are naturally used extensively in every district and would form an excellent index of material progress if reliance could be placed on the figures returned, and if the figures of one period could be regarded as fairly comparable with those of another.

Grouping of the minerals.

In order to obtain some mental impression of progress, we are compelled to exclude from the list of minerals contributing to the statement of total values, those about which we can obtain only partial figures or rough local estimates. The minerals are thus reviewed in two groups as before, namely :—

Group I.—Those for which approximately trustworthy annual returns are obtainable ; and

Group II.—Those regarding which regularly recurring and full particulars cannot be procured.

As the methods of collecting the returns become more precise from year to year and the machinery employed for the purpose becomes more efficient, the minerals included in Group I tend to increase in number ; that group now comprises :—

Chromite.	Graphite.
Coal.	Iron.
Copper.	Jadeite.
Diamonds.	Lead.
Gold.	Magnesite.

Manganese.	Salt.
Mica.	Saltpetre.
Monazite.	Silver.
Petroleum.	Tin.
Ruby, Sapphire and Spinel.	Tungsten.
	Zinc.

Units recognised.

Unless otherwise stated, the ton referred to in this review is the English statute ton of 2,240 lbs. Where there are totals likely to be of interest to foreign readers weights are also expressed in metric tons of 1,000 kilogrammes each (equal to 0·981 statute ton). Returns in *maunds*[1] have been translated into tons, hundredweights and quarters throughout. The output of petroleum has been given in Imperial gallons, and totals are expressed also in metric tons, on the assumption that one metric ton is equivalent to 249 gallons of crude oil of an average specific gravity of 0·885. Values in sterling are calculated throughout at the approximate average rate of exchange for the particular year; this rate of exchange is indicated in each case.

Sources of information.

The data employed in this review have been obtained from various sources. Before the year 1901 the Annual Statistics of Mineral Production were published by the Director-General of Statistics. Since then the figures of mineral production for India have been published annually in the Records of the Geological Survey of India. Returns of mineral production are now sent by Local Governments, Political Agents and in a few cases by Indian Durbars, direct to the Director of the Geological Survey, except in the case of mines under the Mines Act, when the figures are forwarded direct by mine-managers to the Chief Inspector of Mines, who forwards a summary to the Geological Survey. Information regarding exports and imports has been derived from the publications issued by the Director of Statistics. Additional information has been obtained from the following sources:—

(1) Annual Returns of the Chief Inspector of Mines in India, and the Chief Inspector of Mines for Mysore;
(2) Annual Administration Reports of the various Local Governments and Local Administrations in India;
(3) Annual Administration Reports of the Railway Board;

[1] One *maund* = 82·3 lbs.

(4) Returns issued by the various Geological Surveys and Statistics relating to Mines and Quarries, published by the English Home Office.

We are also indebted to the Managing Agents of several Mining Companies for much information supplied direct.

II.—SUMMARY OF PROGRESS.

[E. H. PASCOE.]

Total values.

Table 1 summarises the output and value of the principal minerals produced during the five years under review. The total values have the obvious defect of being the addition of unlike denominations. In the first place, with an exchange varying from 1*s.* $2\frac{1}{16}$*d.* to 2*s.* $10\frac{1}{2}$*d.* per rupee, and a no less marked variation in the actual intrinsic value of the minerals due to disturbed markets and accumulated stocks, combined with the enhanced effect caused by the lack of synchronism between the time of purchase and the time of payment, statistics lose much of their precision. In the second place, export values, being the only returns obtainable in some cases, are ranged with spot values, while the latter necessarily vary with the position of the mine, representing not the *values* but the *prices* obtainable. In the case of coal, for instance, the so-called value of a ton of good coal in Bengal is less than half that of the inferior material raised in Baluchistan; in the case of salt, the values given are the prices charged, and are less than the duty, which is the principal value of the salt to Government; certain valuable mineral products, such as building stones, are omitted altogether for want of any but very approximate estimates.

The values returned for minerals exported are also necessarily lower than they would be if those minerals were consumed in the country, and it is consequently unfair to compare this table of values with corresponding returns for countries in which metallurgical industries flourish. Manganese-ore is a conspicuous example of a product the value of which, to the Indian producer, is reduced by the heavy cost of transport. The country is thus not only so much poorer by the loss of the metal exported in the ore, but is paid in return little more than half its market value.

Comparison with the previous periods:

The imperfections of the table are not only those confessedly inseparable from all such estimates of mineral production, but form part of the aftermath of the war, and more especially of the economic convulsions resulting therefrom. The value of comparison with

other quinquennial periods is largely discounted by the abnormal conditions which prevailed, more especially during the first two years of the quinquennium. These abnormal conditions have led in some cases to greatly reduced output; on the other hand, a remarkable rise in price often masks this effect, and comparison of the figures given in Table 1 with pre-war figures is likely to be misleading in individual cases. But the general trend of the Indian mineral industries is fairly clear, and the advance made during the five years under review is remarkable, the value of the total output being double what it was during the previous period. In the latter the average annual value of the output of minerals for which reliable statistics are available was about £11,800,000, while during 1919-23 it reached £24,600,000. This comparison must be discounted to the extent of the universal rise in price, not only of minerals but of all commodities, and also by the high value of the rupee during 1919 and 1920.

There have been steady increases in the case of coal, petroleum, salt and mica; with regard to the first two, the effect is magnified by inflated prices. The decline in the output of gold recorded during the war period, as a result of the rise in price of all ordinary commodities, was repeated during the five years following. The most marked increases in output and value occurred in the cases of silver, tin and copper, all three more than trebling their previous average annual tonnage. There were large increases also, both in output and value, in iron-ore, chromite and magnesite. There was a fall in the output and value of saltpetre, and a more considerable decline in the cases of tungsten and monazite.

Metallurgical industries.

The stimulating effect of the war on metallurgical industries has persisted. The activities and output of the Tata Iron and Steel works at Jamshedpur were increased, as also were those of the Bengal Iron Company at Kulti. The operations of the Burma Corporation at Bawdwin were also extended and the output of lead and silver very largely increased. The negotiations for the establishment in India of works to treat the zinc concentrates from the same mine with the production of sulphuric acid as a by-product have unfortunately fallen through. Copper-smelting was definitely established at the Rakha Mines during the period under review.

TABLE 1.—*Output and Value of Minerals for which reliable Returns of Production are available for the years 1919 to 1923.*

Mineral.		1919. (£1=Rs. 11-5)	1920. (£1=Rs. 10)	1921. (£1=Rs. 15)	1922. (£1=Rs. 15)	1923. (£1=Rs. 15)	*Average.*
Coal . . .	£ tons	8,799,353 22,628,037	9,297,853 17,962,214	8,673,377 19,302,947	9,755,343 19,010,986	9,737,316 19,056,883	*9,252,649* *19,712,213*
Petroleum . .	£ gals.	7,308,274 305,749,138	8,017,820 293,116,834	5,644,988 305,683,227	7,202,494 298,504,125	7,007,915 294,215,053	*7,036,298* *299,453,675*
Gold . . .	£ oz.	2,127,708 507,261	2,733,116 499,068	2,050,575 432,723	1,857,577 438,015	1,702,642 422,307	*2,094,323* *459,875*
Manganese-ore (*a*).	£ tons	959,118 382,116	3,525,842 805,839	1,207,272 530,371	1,628,060 877,194	2,656,412 814,342	*1,995 341* *681,972*
Salt (*b*) . .	£ tons	1,368,854 1,891,138	1,229,746 1,630,123	648,279 1,533,679	744,966 1,653,898	749,382 1,781,156	*948,245* *1,697,998*
Mica (*c*) . .	£ cwt.	750,824 59,098	1,065,438 76,517	426,274 30,944	385,683 43,145	538,436 83,296	*633,331* *58,600*
Lead and lead-ore	£ tons	581,427 19,218	975,927 23,909	784,586 33,856	945,137 39,204	1,121,474 46,093	*881,710* *32,468*
Tungsten-ore .	£ tons	453,212 3,570	139,707 2,346	29,292 898	25,035 943	31,979 872	*135,845* *1,726*
Silver . . .	£ oz.	423,692 2,165,607	843,109 2,906,397	593,008 3,587,587	675,234 4,244,304	677,207 4,863,066	*642,450* *3,553,392*
Saltpetre . .	£ tons	443,082 19,715	590,854 16,874	357,032 15,894	234,866 11,673	149,757 8,555	*355,118* *14,542*
Tin and Tin-ore .	£ tons	218,904 1,706	316,221 2,282	162,770 1,873	188,963 2,092	185,641 2,007	*214,500* *1,992*
Iron-ore . .	£ tons	(*d*)75,218 563,750	(*d*)118,163 558,005	(*d*)140,555 942,084	104,429 625,274	136,415 804,384	*114,956* *698,699*
Ruby, Sapphire and Spinel.	£ carats	93,989 158,577	61,982 155,604	50,164 193,915	48,487 231,160	48,679 187,010	*60,660* *185,253*
Jadestone (*e*) .	£ cwt.	83,769 3,821	180,728 5,094	126,535 5,374	124,811 5,762	55,803 3,088	*114,329* *4,628*
Chromite . .	£ tons	77,151 36,439	79,970 26,801	36,492 34,762	24,086 22,777	51,119 54,242	*53,764* *35,004*
Monazite . .	£ tons	60,712 2,024	49,231 1,641	30,959 1,260	1,871 125	3,697 246	*29,291* *1,059*
Copper ore . .	£ tons	45,579 32,759	42,250 28,167	32,560 32,190	20,509 30,894	4,367 6,550	*29,053* *26,174*
Diamonds . .	£ carats	18,109 312	4,125 85	4,865 126	6,110 171	3,100 115	*7,262* *162*
Magnesite .	£ tons	17,155 17,126	17,216 14,346	15,632 20,017	16,046 19,273	15,622 19,436	*16,334* *18,039*
Graphite . .	£ tons	712 127	560 100	52 25	.. 20	.. ..	*265* *54*
TOTAL VALUE	£	23,906 842	29,289,858	21,015,267	23,989,707	24,876,962	*24,615,727*

(*a*) Export values of quantities actually exported.
(*b*) Prices without duty.
(*c*) Export figures.
(*d*) Estimated.
(*e*) Figures represent overland trade and exports *viâ* Rangoon combined.

Table 2 shows the values of the more important mineral products of the United Kingdom during the year 1922. The enormous preponderance of the coal industry in the United Kingdom is remarkable, while the next most important mineral product in the world (iron-ore) takes the fifth place. The enormous strides made by the Indian coal trade during the years 1914-1918 have been checked to some extent during the past five years. Although the present output of iron-ore is still comparatively small, it will undoubtedly rise in the near future ; it has been known for some years past that in Singhbhum and other parts of Bihar and Orissa India possesses reserves of iron-ore which will compare in quality and quantity with those of almost any other country in the world.

TABLE 2.—*Values (a) during 1922 of the Twelve Leading Mineral Products in the United Kingdom.*

	£
Coal	219,998,167
Igneous Rocks	2,825,481
Clay (including fire clay) and shale	2,610,085
Limestone	2,532,253
Iron-ore	2,394,021
Slate	1,854,910
Salt	1,591,949
Sandstone (other than Ganister and Silica rocks)	1,273,296
Oil Shale	1,046,760
Gravel and Sand	337,386
Chalk	294,747
Gypsum	252,079

(*a*) Value at mine or quarry.

Imports of minerals and mineral products.

In this place, also, it will be interesting to note the values recorded for imported minerals and for products obtained directly from minerals, during the period under review. These figures, exclusive of the values of cutlery and hardware, machinery and millwork, railway plant and rolling stock, earthenware and porcelain, glass and glassware, jewellery and plate of gold and silver, paints and colours, and alizarine and aniline dyes, are shown in Table 3. The corresponding table in the previous review showed the effects of the war on imports, which in the majority of metals and mineral products fell considerably— in some cases to a half or quarter of what they were just before the war. The present table shows a recovery in the case of every specified commodity with the exception of lead, quicksilver, paraffin and stone and marble, but the recovery is in most cases insufficient to bring the figures up to what they were in 1914, whose statistics may be taken as very little below normal

pre-war figures. The most striking features of this table are the conspicuously high imports in 1920, a "bumper" year, the enormous rise in the imports of brass which averaged nearly 17 times the figure for 1914, and the marked decline during the last three years of the period in the imports of lead owing no doubt to the increased utilization of the supplies from Burma. Table 4 is even more instructive. The remarkable fall in the value of the imports of railway material during the war period from nearly £10,000,000 in 1914 to a little over £500,000 in 1917 was eloquent of the difficulties that the railway companies had to face; the fall was due to difficulty in procuring those imports and not to any decreased demand. The effect, it was hoped, would make India more self-supporting and create industries that, in normal circumstances, might not have arisen for many years. A number of new engineering companies were stimulated into existence and the dividends paid by those already established rose to unprecedented amounts. This stimulus to Indian industries proved, however, to be a flash in the pan, as witness the position of Indian engineering companies to-day. Table 4 will show that imports of railway plant and rolling stock are practically back to the pre-war figure, while those of machinery and millwork greatly exceed the figure for 1914. The set-back to the Indian steel industry may be looked upon as largely due to the immense increase in the world's steel manufacturing capacity as a result of the war and the equally immense decrease in consumption caused by the cessation of hostilities. Many of the continental steel manufacturers have been forced to produce at a minimum profit or even at a loss in order to keep their works occupied, and the market price of steel has been consequently lowered to such a point that India, with her lack of skilled and technical labour, has found herself to be, temporarily at least, an unsuccessful competitor.

Summary of the Minerals of Group I.

Chromite.

Chromite being a munition of war, its production during the war period rose from an annual average of 4,671 tons to nearly 23,000 tons; during the quinquennium under review it again rose from the latter figure to 35,000 tons. The rise was due principally to the vigorous mining in Baluchistan which doubled its output from 10,278 tons in the preceding quinquennium to 20,358 tons in the period under consideration. The average annual outputs of Mysore and Bihar and Orissa remained almost the same as in the previous period, 1914-1918.

TABLE 3.—*Amount and value of Imports of Minerals and Products obtained directly from Minerals for the years 1919 to 1923 (including Government Stores).*

		1919.	1920.	1921.	1922.	1923.	*Average.*
Salt . . .	Rs. tons	2,31,11,680 481,749	2,36,98,970 612,793	1,57,94,763 477,325	1,56,17,058 507,073	1,32,98,703 508,740	*1,83,04,235* *517,536*
Metals—							
Brass . . .	Rs. cwt.	1,63,44,410 195,127	4,95,47,540 746,381	1,54,25,582 224,558	2,94,53,110 513,331	2,39,08,979 422,109	*2,69,35,924* *420,302*
Copper . .	Rs. cwt.	1,93,50,620 235,145	3,85,14,840 503,901	1,40,64,937 172,369	2,16,41,137 307,352	1,57,64,704 244,612	*2,18,67,248* *292,680*
German Silver .	Rs. cwt.	20,370 197	6,98,130 5,934	10,52,197 5,974	14,19,097 12,344	9,92,445 7,286	*8,36,448* *6,347*
Iron . . .	Rs. tons	56,07,390 15,259	1,08,11,210 37,210	71,56,836 29,919	85,01,555 50,338	37,94,513 22,873	*71,92,301* *31,120*
Iron or Steel .	Rs. tons	13,26,60,380 275,876	21,15,67,140 403,689	19,86,63,063 404,158	15,81,88,446 518,682	14,46,81,787 525,749	*16,91,52,163* *443,629*
Steel . .	Rs tons	2,26,70,560 58,349	6,24,57,130 195,413	4,16,45,731 150,247	3,56,61,259 204,679	3,13,60,486 207,025	*3,87,59,033* *163,143*
Lead . . .	Rs. cwt.	33,46,970 111,822	29,10,320 107,343	18,06,958 54,175	16,68,252 56,077	15,86,292 57,513	*22,63,758* *77,386*
Quicksilver . .	Rs. lb.	18,43,800 480,853	6,36,660 202,855	3,50,963 157,143	3,02,502 134,106	8,32,874 362,264	*7,93,360* *267,444*
Tin . . .	Rs. cwt.	85,86,400 49,232	83,58,120 53,716	85,47,748 59,517	47,61,750 39,400	73,82,972 58,334	*75,27,398* *52,040*
Zinc . . .	Rs. cwt.	20,28,340 82,788	49,66,000 143,328	26,21,337 99,704	24,42,626 93,543	30,77,694 113,895	*32,07,319* *106,652*
Unenumerated .	Rs. cwt	31,37,120 31,306	67,03,910 74,554	10,15,821 18,755	5,84,904 10,921	9,26,077 13,118	*24,73,566* *29,731*
Total value of metals .	**Rs.**	**21,65,86,360**	**39,71,71,600**	**29,23,51,173**	**26,46,24,638**	**23,43,08,823**	**28,10,08,518**
Inorganic Chemicals .	Rs.	2,01,19,340	2,47,43,210	2,21,55,395	2,13,55,318	1,95,35,007	*2,15,81,660*
Mineral Oil . .	Rs. gals.	8,52,11,560 131,801,309	7,93,40,060 123,101,139	7,45,99,869 113,620,643	7,47,57,783 140,135,002	7,62,92,283 153,329,964	*7,80,40,311* *132,397,611*
Paraffin . . .	Rs. cwt.	4,620 160	6,510 140	37,163 960	85,154 3,620	41,662 2,240	*35,022* *1,424*
Coal, Coke and Patent Fuel.	Rs. tons	14,27,070 48,880	12,93,010 39,727	5,05,63,748 1,299,756	6,40,78,112 1,712,467	1,88,23,839 629,169	*2,72,37,156* *732,000*
Precious Stones and Pearls, unset.	Rs.	58,71,030	57,77,270	69,88,782	1,95,38,261	2,05,48,253	*1,17,44,719*
Stone and Marble	Rs. tons	5,35,730 5,301	12,24,720 11,289	6,98,947 7,452	7,87,079 3,829	6,28,217 5,255	*7,74,939* *6,627*
Other Building Materials	Rs.	1,00,17,250	2,13,17,930	2,04,50,776	1,69,06,228	1,38,65,988	*1,65,11,634*
TOTAL VALUE	**Rs.**	**36,28,84,640**	**55,45,73,280**	**48,36,40,616**	**47,77,49,661**	**39,73,42,775**	**45,52,38,194**
" "	**£**	**31,555,187**	**55,457,328**	**32,242,708**	**31,849,977**	**26,489,518**	**35,518,944**
		(£1 = Rs. 11·5)	(£1 = Rs. 10)	(£1 = Rs. 15)	(£1 = Rs. 15)	(£1 = Rs. 15)	

TABLE 4.—*Value of Imports of Products of a more finished nature manufactured almost entirely from Minerals or Mineral Products for the years 1919 to 1923 (including Government Stores).*

	1919.	1920.	1921.	1922.	1923.	*Average.*
	Rs.	Rs.	Rs.	Rs.	Rs.	*Rs.*
Railway Plant and Rolling Stock . .	7,21,71,680	12,24,75,150	22,74,09,591	16,69,04,071	12,70,09,736	*14,31 94,046*
Machinery and Millwork	9,29,62,270	16,95,56,400	34,99,59,458	28,51,93,144	21,79,23,239	*22,31,18,902*
Cutlery and Hardware	5,69 62,350	9,36,37,580	8,46,17,142	6,30,72,156	5,19,99,881	*7,07,57,822*
Glass and Glassware	1,65,79,980	3,41,23,920	2,45,99,376	2,50,05,054	2,57,22,336	*2,52,06,133*
Alizarine and Aniline Dyes	1,20,35,300	2,76,12,580	3,17,23,245	2,73,34,225	2,28,18,372	*2,43,04,744*
Paints and Colours	1,04,21,890	1,41,18,980	1,11,66,054	1,09,34,446	1,03,84,963	*1,14,05,266*
Earthenware and Porcelain . . .	(a) 65 52,440	88,06,320	77,02,800	83,20,297	72,07,557	*77,17,883*
TOTAL VALUE . . Rs.	**26,76,85,910**	**47,03,30,930**	**73,71,77,666**	**58,67,63,393**	**46,30,66,084**	**50,50,04,796**
,, ,, Sterling	**£23,277,036**	**£47,033,093**	**£49,145,178**	**£39,117,559**	**£30,871,072**	**£37,900,788**
	(£1 = Rs 11-5)	(£1 = Rs. 10)	(£1 = Rs. 15)	(£1 = Rs 15)	(£1 = Rs. 15)	

(a) Relates to nine months only.

Coal.

In the case of coal, the output which had increased throughout the previous period and culminated in a figure of nearly 21 million tons, rose to over 22½ million tons in 1919. In 1920 it fell to about 18 million and during the final three years maintained a steady level between 19,000,000 and 19,660,000 tons. During the war, there was a marked rise in raising costs, and the pit's mouth value rose from Rs. 3-9-0 to a record figure of Rs. 4-6-0 in 1918. This figure has duri g the period under consideration been altogether eclipsed by that for 1922, which reached Rs. 7-11-0 per ton. In 1923 it fell to Rs. 7-7-0, which is still more than double the pre-war rate. The increase in value of the output during the past quinquennium is therefore much greater relatively than the increase in quantity.

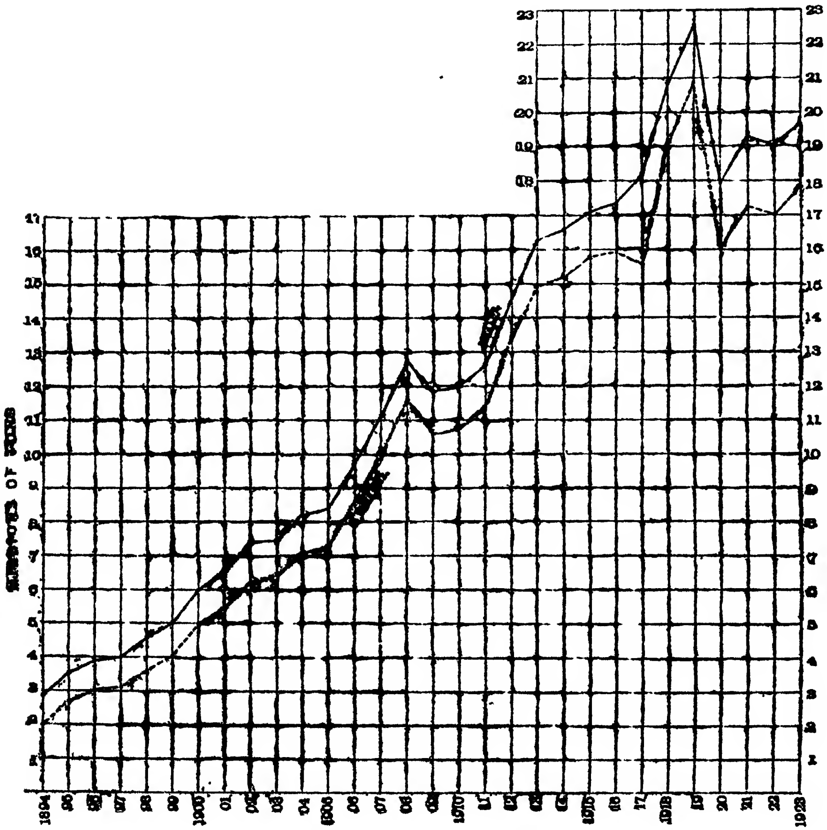

FIG. 1.—*Production of Coal from 1894-1923.*

For at least the first four years of the period, India still held her position as the largest coal-producer of any of the British dependencies: figures for other dependencies are not yet available for the last year, but her production in 1922 was considerably greater than that of any other dependency. She was again completely outdistanced by Japan, whose output in 1919 was about 30½ million tons against India's 22½ millions. The Gondwana fields produced over 98 per cent. of the Indian output, and the Raniganj and Jharia fields respectively 28 and 52 per cent. The Bokaro field contributed on an average 4·7 per cent. of India's total output, and has now surpassed the Giridih and Singareni fields. Before many years this is likely to prove one of the great Indian fields.

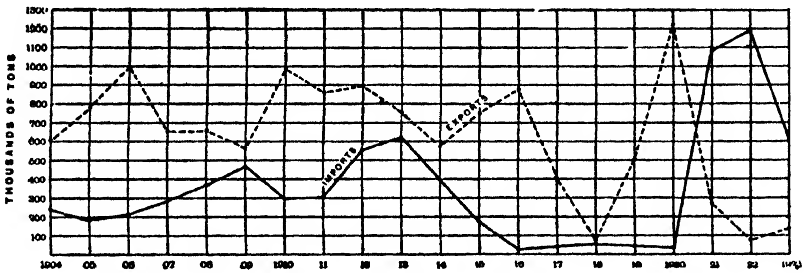

FIG. 2.—*Exports and Imports of Coal for the past 20 years.*

As might be expected, imports and exports of coal were abnormally low throughout the war period and fell to about 54,000 tons and 74,000 tons respectively in 1918. Imports fell still lower in 1919 and 1920, in the latter year not amounting to 40,000 tons; in 1921 there was a jump to over 1 million tons which increased in the following year but fell to 625,000 tons in 1923. A Committee is at present considering the advisability of protecting the Indian coal industry by a tariff on imported coal. Exports show a similarly extreme variation, the highest figure being that for 1920, 1¼ million tons, and the lowest that for 1922, 77,000 tons. Both Japan and South Africa must be regarded as formidable rivals in Indian Ocean ports.

Recently the employment of by-product ovens in coke-making has extended considerably. For many years the East Indian Railway Company's Simon-Carvès ovens at Giridih constituted the only

by-product plant in India; batteries have now been installed at Jamshedpur, Kulti and the Jharia coalfield. The by-products recovered are tar and ammonia, sulphate of the alkali being manufactured with acid made locally from imported sulphur.

One of the outstanding improvements adopted during the past five years in the coalfields is the greatly extended use of electricity for pumping, ventilation, haulage, coal-cutting, etc., especially for the first mentioned purpose. During the year 1922 no less than 89 of the Indian coal mines were making use of electricity.

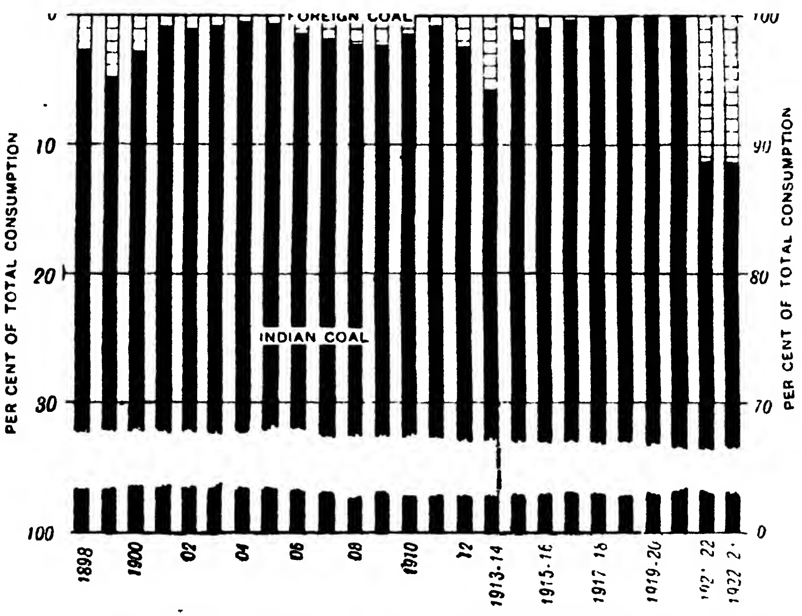

FIG. 3.—*The relative consumption of Foreign and Indian coal on Indian Railways.*

Copper began to figure regularly in our mineral returns during the previous quinquennium; unfortunately, the Cape Copper Company's operations at the Rakha Mines were delayed by the difficulty of importing materials for furnaces, etc., during the war, and the production, which had risen to 20,000 tons in 1917, fell to only 3,600 tons in 1918. Smelting operations were begun in 1918 and a small amount of blister copper produced, but the average annual output for that

Copper.

period was below 8,054 tons. During the period under consideration, the average annual output of copper ore by the Cape Copper Company has risen to 26,159 tons. The amount of blister copper produced by the Company ranged from 512 tons in 1920 to 1,037 tons in 1922.

Diamonds.

The average annual output of diamonds rose from 42 carats in the preceding quinquennium to 162 carats in the period under report.

Gold.

Gold-mining, as might be expected, was one of the few mineral industries that suffered from the war. The Indian output fell steadily from 1915 onwards, and the output decreased by over 80,000 oz. in 1918. The average annual production for the war period was a little under 587,000 ounces. The fall in the output of gold has steadily continued during the period under review from 507,261 oz. in 1919 to 432,723 oz. in 1921. The output rose to 438,015 oz. in 1922 but fell again to 422,307 oz. in 1923. The average annual output amounted to 459,875 oz. or 126,704 oz. less than that of the preceding quinquennium. The deficit is to a large extent due to the closing down in 1921 of the gold mines in the Hyderabad State operated by the Hutti (Nizam's) Gold Mines, Limited, and to the lack of output from Myitkyina (Burma) by the Burma Gold Dredging Company, who ceased operations at the beginning of the period.

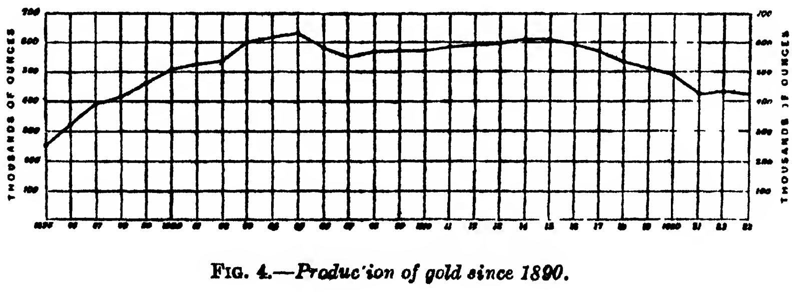

FIG. 4.—*Production of gold since 1890.*

Graphite.

Owing to the difficulty of obtaining graphite from extra-Indian sources, there had been a slight revival of indigenous mining during the previous period, but it has not persisted. The output of graphite amounted to 127 tons in 1919, 100 tons in 1920 and 25 tons in 1921. The production was

derived from Patna and Kalahandi States in Bihar and Orissa, Betul in the Central Provinces and Ajmer-Merwara in Rajputana. But for a small output of 20 tons from Mysore the industry would have died out in 1922. There was no production in 1923. No attempt has been made to open the Travancore mines.

Iron.

In the period under review, there has been a big advance in the Indian iron and steel trade, and one new company has commenced to produce pig iron. The Bengal Iron Company's outputs of pig iron and castings, which were respectively 92,250 tons and 30,605 tons in 1916, had fallen at the end of the last quinquennium to 49,348 tons of pig iron and 21,776 tons of castings, but regained its former position by 1920, and during 1923 the outputs had increased to 119,379 tons of pig iron and 33,627 tons of castings. Naturally the quantity of ore used varied in a similar manner, and fell from 143,922 tons in 1916 to 84,057 tons at the close of the period ; by 1920, however, it had reached its former level, and in 1923 there was a big increase to 208,866 tons. The Tata Iron and Steel Company practically doubled their output during the last five years. In 1918 their output of pig iron was 198,061 tons and of steel 130,043 tons, whilst in 1923 it was 392,135 tons of pig iron, 187,974 tons of steel ingots and 178,987 tons of Blooming mill blooms, etc. The quantity of iron ore used increased from 338,936 tons in 1918 to 663,217 tons in 1923. Of the two new companies said to have been formed towards the end of the last quinquennial period, the Indian Iron and Steel Company commenced smelting operations at the end of 1922. The second company, the United Steel Corporation of Asia, Limited, has not yet commenced work. As a result of representations from the Tata Iron and Steel Company, the Government of India appointed a Tariff Board to enquire into the question of protection. The conclusion of the Board, after exhaustive enquiry, was that, without some form of protection, the Indian Steel Industry would certainly not develop for many years and might even cease to exist. The recommendations of this investigation and the resultant enactment were made subsequent to the quinquennial period under review.

Jadeite.

There has been no real advance in the jadeite industry, which is a primitive one carried on in unadministered territory in the neighbourhood of the Hukong. There was a slight decrease in the average annual exports

which amounted to 4,628 cwts. against 4,651 cwts. in the preceding quinquennium; the value, however, rose from Rs. 240 to Rs. 319 per cwt.

Lead and Silver.

There has been further marked progress in the operations of the Burma Corporation, Limited, at Bawdwin and Namtu, the property being now proved as one of the great lead-silver-zinc mines of the world. The output of lead extracted from the ore rose steadily from 19,000 tons in 1919 to 46,000 tons in 1923. The output of silver also increased from over 2 million oz. in 1919 to about 5 million oz. in 1923.

Magnesite.

The average annual output of magnesite increased by 77 per cent. in the period under consideration. The production was derived mainly from the deposits in Salem, Madras, with a small contribution from Mysore.

Manganese.

With respect to manganese India in 1907 overtook Russia, which was at that time the greatest producer of that mineral, and assumed the first place amongst the world's producers of manganese-ore (see fig. 13, p. 200). This lead was lost during the years 1912 to 1915, but the war reinstated India in its former supremacy, in spite of increased competition from Brazil due to the same cause, and the events of the post-war period have not yet led to any change in the relative position of these three leading producers. The record for the present period has been that of a relatively stable industry that has found its level in the world, the annual fluctuations in output being relatively small and due to changes in market price and rates of freight, and to the gradual development of some deposits and exhaustion of others. The period of discovery of new and valuable deposits of manganese-ore seems to have passed. During the five years 1919-23 the annual production of manganese-ore varied between 474,401 and 736,439 statute tons with an annual average of 624,635 statute tons, the average annual figures for the two previous quinquennia being 577,457 statute tons in 1914-18 and 712,797 statute tons in 1909-13.

Reliable figures for the Russian manganese-ore production are difficult to obtain. Exports from that country from the middle of 1914 up to the end of 1921 were negligible, but business was resumed again in 1922 and steadily increased in 1923. The exports for 1922 amounted to some figure between 80,000 and 170,000 tons; in 1923 they increased to about 350,000 tons. As before the war the bulk of

the ore came from the Chiaturi region of Georgia. Although there is good reason to suspect that the greater part of the recently exported ore was derived from accumulated stocks, with proper organization Russia could probably maintain a leading position, especially should modern means of exploitation supersede the somewhat primitive methods of the past.

The immediate serious rival will be Brazil, where, however, inadequate transport facilities are said to act as a retarding influence to the progress of the industry. There is a probability that the next few years will witness a considerably increased output of ferruginous manganese-ore from Sinai in Egypt and of first-grade manganese-ore from the Gold Coast. The latter will compete with Indian ore but the magnitude of the West Africa output is not likely to be sufficient to affect India seriously. During the five years 1908 to 1912 the Indian and Russian productions constituted respectively 43·8 per cent. and 37·2 per cent. of the world's output of manganese-ore, which averaged 1,586,414 metric tons annually. During the five years 1918 to 1922 the proportions contributed by India, Brazil, the United States of America, and Russia, in the order named were 42·4 per cent., 23·6 per cent., 6·9 per cent. and 6·2 per cent., respectively, of the world's output which averaged 1,388,814 statute tons annually. The position of the United States is due to an abnormal output of 305,869 tons in 1918, promoted by war conditions, a figure which will probably never again be approached unless the stimulating conditions are repeated. The United States output for 1923 was 32,000 tons.

The average annual value of the ore produced in India during the years 1909-13 was £822,876. This increased to £1,052,403 for the period 1914-18, and again to £1,995,341 during 1919-23, the maximum value being £3,525,842 in 1920. Taking the average values for the period, manganese-ore maintains a fourth position amongst the minerals produced in India, being exceeded by coal, petroleum and gold.

From figure 5 it is seen that the output of the Central Provinces has increased slightly during the period 1919-23, whilst that of Bombay shows a considerable proportionate increase Gangpur in Bihar and Orissa shows a partial recovery from the fall noted in the previous review, whilst Madras shows a small recovery due to the return of some activity in Vizagapatam and the resumption of work in Sandur towards the end of the period. Mysore again shows a slight falling-off.

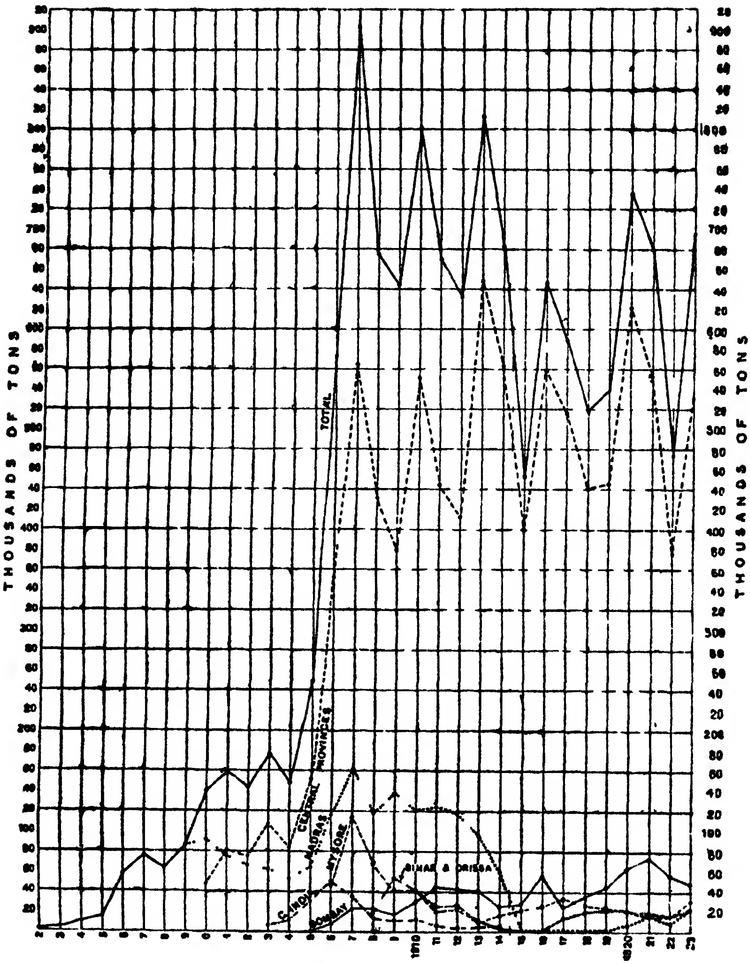

FIG. 5.—*Production of Manganese ore since the commencement in 1892.*

Mica.

India is still the greatest mica-producing country in the world; her output is double that of other producing countries, of which Canada and the United States are of importance. The production of fine splittings by hand is an art which is performed to perfection in India. In fact, owing to the brisk demand for mica splittings during the last three

years of the quinquennial period, a certain amount of mica has been imported into India from the United Kingdom, United States and Japan for conversion into fine splittings and subsequently exported. India also holds a monopoly in the production of shellac, and has it in her power to hold a predominant position in the manufacture of micanite, an artificial commodity made out of the smallest thinnest films of mica cemented together with shellac dissolved in spirit. Figure 6 shows the fluctuations in the total weight and total value of the mica exported during the past twenty years.

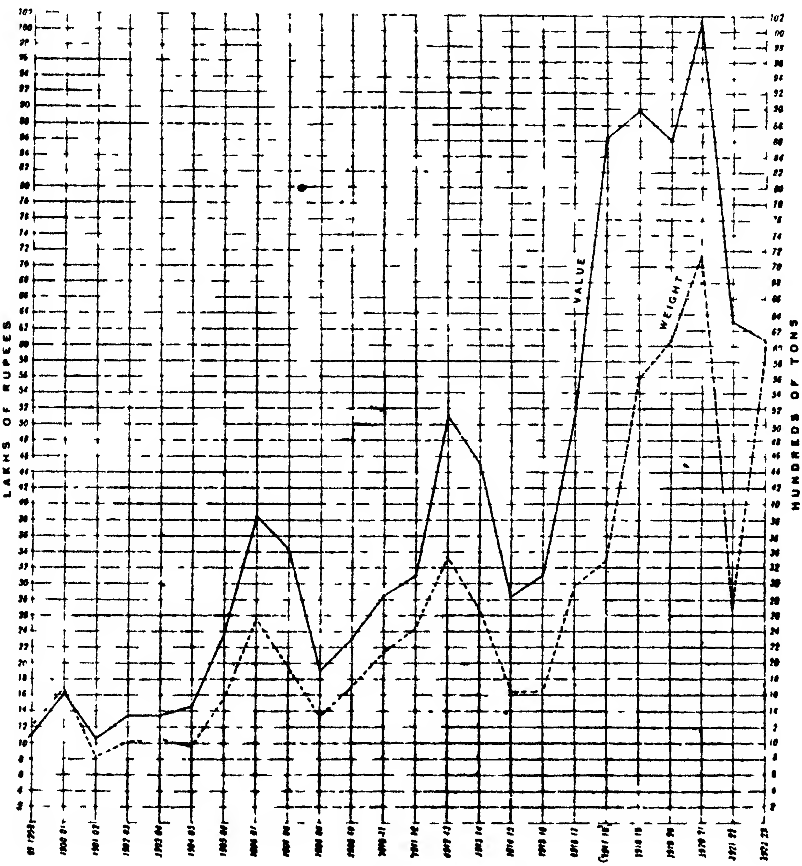

FIG. 6.—*Exports of Indian Mica during the years 1899-1900 to 1922-23.*

Monazite.

There was a steady decline in the production of monazite in Travancore, which fell from over 2,000 tons in 1919 to only 125 tons in 1922. The industry recovered slightly in 1923, when the output rose to 246 tons.

Petroleum.

The average annual value of petroleum produced has increased from £1,073,604 for the period of the preceding review to £7,036,298 for the present period. The increased output and the high exchange value of Indian currency prevailing in 1919 and 1920 partially account for this large increase in the average annual value, but the latter is principally due to the fact that in the years previous to 1919 the value of petroleum was greatly under-estimated in India. The exports of paraffin wax rose from 532,480 cwts. in 1919 to 621,160 cwts. in 1921 but fell to 491,280 cwts. in 1923.

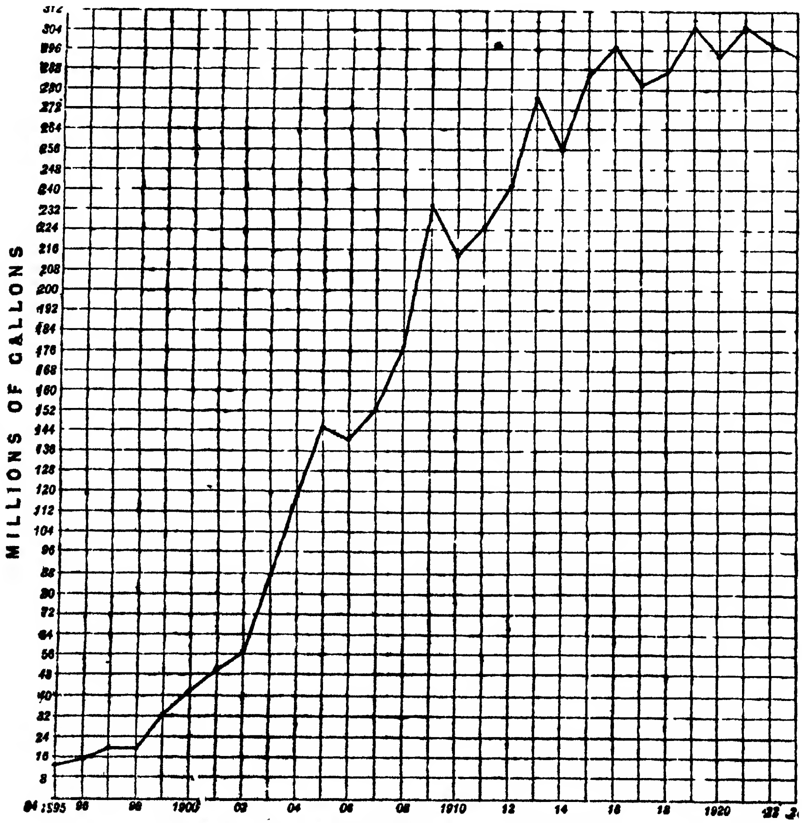

Fig. 7.—*Production of Petroleum since 1895.*

Ruby, Sapphire, and Spinel.

Next to petroleum rubies used to form the chief source of revenue amongst the mineral products of Burma. In recent years, however, the industry has been outstripped by those of silver, lead, tin and, until the last few years, tungsten. The Burma Ruby Mines, Limited, paid formerly an annual rent of two lakhs of rupees (£13,333) and a royalty of 30 per cent. of their annual net profits. These terms were subsequently modified owing to continued depression in the industry. The average value of the annual output of rubies, sapphires and spinels for the period under review was £60,660, as compared with £41,817 during the preceding period.

Salt.

The amount of salt produced annually during the period 1919-23 has amounted on an average to about 1,698,000 tons, which shows an increase of 125,000 tons over that of the previous quinquennium. The annual imports increased from 443,575 tons in 1914-18 to 511,318 tons in 1919-23.

Saltpetre.

It was noted in the last quinquennial review that the figures for the production of saltpetre were apparently understated, being lower than the quantities returned as exports. It has been discovered that the discrepancy is mainly due to the fact that the production of *kuthea* (unrefined saltpetre) was not taken into account in the past. *Kuthea* returns are included in the tables of production in the present review (see Tables 90 and 91). The average production amounted to 14,542 tons and the average exports to 14,271 tons. Of the amounts exported during the period under review 30 per cent. went to the United Kingdom, 19 per cent. to Ceylon, 18 per cent. to Mauritius and its dependencies, 15 per cent. to Hongkong and the remainder to the United States, Japan and other countries.

Tin.

In contrast with the stagnation of the sister industry of wolfram, tin mining has progressed steadily during the five-year period 1919-23. The high price of tin has played an important part in the increased output, which rose from an average annual figure of 116 tons valued at Rs. 3,38,040 during the war period to 138 tons valued at Rs. 4,15,295 during the five years under review. The collapse of the wolfram market also induced more attention to tin. Much of the work had originally been carried out on primitive native principles, but dredging machinery

was subsequently introduced, and many of the alluvial flats in Tavoy and Mergui have been and are being systematically tested.

Tungsten.

The large quantities of high-speed tool-steel required throughout the world in consequence of the war, led to a greatly increased demand for tungsten and its raw materials, wolfram and scheelite. In 1913 the wolfram industry in Burma was only four years old and the output only 1,688 tons. At that time Germany was the only manufacturer of tungsten powder and the Allies had previously been dependent on her for their supplies. Immediate steps were therefore taken to set up tungsten works in England, and the whole wolfram and scheelite output of the British Empire was commandeered. Vigorous measures were taken to increase production in Burma; by the year 1917 the output had been more than doubled and amounted to 4,542 tons. The value rose in even greater proportion from £175,150 in 1914 to £726,681 in 1918. These figures, however, were artificial; the price per unit was fixed by the British Government at a figure considerably above the previous market rate and all wolfram was taken over at that price. This, although highly profitable to the producer, did not represent the true market value of the material, the price offered in the American market being nearly double the control rate. During the period under review the wolfram market suffered an expected collapse, and mining operations in Burma dwindled to an output of under 900 tons in 1921. There has been a steady recovery since, but not on the same scale as that experienced in China, which country in 1922 turned out 7,000 metric tons of 60 per cent. wolfram concentrates.

III.—DETAILED ACCOUNT OF THE MINERALS OF GROUP I.

Chromite.

[E. H. Pascoe.]

Occurrences of chromite in India are usually associated with serpentine and other rocks of the peridotite family, and are known in Baluchistan, in Mysore, in the Singhbhum district of Bihar and Orissa, near Salem in Madras and in the Andaman Islands. Serpentine and peridotite are found in large quantities in the Minbu district, in Manipur[1] and further north in the direction of Sarameti peak in the heart of the Arakan Yoma[2] ; the chances of discovering chromite in the last mentioned locality are good, though none has so far actually been reported. The deposits at Karuppur in the "Chalk Hills" near Salem have been known for a long time, and attempts were made many years ago to work them but were given up. The mineral is found in very thin veinlets lying either amongst the magnesite or between the magnesite and the wall of the magnesite vein. Veins of chromite of some size must, however, occur somewhere in these hills, for in many of the streams pieces of the mineral ranging up to a foot across have been picked up.[3] The ore, of which some 100 tons were removed during the earlier half of the last century, yielded on analysis 49 per cent. Cr_2O_3. According to Holland the chromite is here associated with intrusions of dunite. A small vein of chromite, 4 inches thick, crops out in the Kanjamalai Hill near by.

Blocks of chromite were found near the village of Chakargaon near Port Blair in the Andaman Islands, but the mineral was not found *in situ* and appeared to be confined to one spot; no attempt has been made to work it.[4] No trace of chromite has been found in the serpentine series of the Middle Andaman during a recent survey.

[1] R. D. Oldham; *Mem. Geol. Surv. Ind.*, XIX, pp. 224-225.
[2] E. H. Pascoe; *Rec. Geol. Surv. Ind.*, XLII, p. 258.
[3] C. S. Middlemiss, *Ibid*, XXIX, p. 34.
[4] *Ibid*, XVI, p. 204 and XVIII, p. 83.

Chrome iron ore was noted in Baluchistan by Vredenburg in 1901, who reported its occurrence in segregated masses of serpentine along the hills bordering the Zhob Valley and in the upper valley of the Pishin river. In one spot, some two miles east of Khanozai, a mass of almost pure ore measuring about 400 feet in length and 5 feet in breadth, was found. Work was commenced in 1903, the production for the first year being returned as 284 tons. The industry received a gigantic impetus during the Great War and the output rose in 1918 to nearly 23,000 tons. In 1919 it was affected by the general slump which succeeded and fell to about 13,200 tons. In 1920 it recovered itself, and in the following year the amount obtained reached the figure of over 25,000 tons. The output for the two producing districts, Quetta-Pishin and Zhob, is shewn in Table 5. The annual average output of Baluchistan for

TABLE 5.—*Production of Chromite during the years 1919 to 1923.*

PROVINCE.	1919.		1920.		1921.		1922.		1923.		*Average.*	
	Quantity	*Value.*	Quantity	*Value.*	Quantity	*Value.*	Quantity	*Value.*	Quantity	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Baluchistan—												
Quetta-Pishin	..	..	..	..	..	..	..	..	1,257	*6,364*		
Zhob . .	13,223·3	*4,29,757*	20,577	*6,68,744*	25,122	*3,76,826*	18,548	*2,88,227*	23,062	*3,39,453*	20,357·8	*4,21,874*
Bihar and Orissa—												
Singhbhum .	843·8	*12,721*	2,546	*57,394*	2,605	*52,610*	1,147	*15,660*	914	*11,977*	1,611·2	*30,672*
Mysore—												
Hassan .	20,786	*4,15,720*	3,400	*68,000*	6,486	*1,16,748*	2,120	*38,160*	25,604	*3,68,262*	11,679·2	*2,01,378*
Mysore .	1,586	*29,046*	278	*5,560*	549	*1,198*	962	*19,240*	3,405	*40,735*	1,356·0	*19,156*
TOTAL .	**36,439·1**	*8,87,244*	**26,801**	*7,99,698*	**34,762**	*5,47,382*	**22,777**	*3,61,287*	**54,242**	*7,66,791*	**35,004·2***	*6,72,480*
Total value in sterling.		*£77,151* (£1 = Rs. 11·5)		*£79,970* (£1 = Rs. 10)		*£36,492* (£1 = Rs. 15)		*£24,086* (£1 = Rs. 15)		*£51,119* (£1 = Rs. 15)		*£53,764*

the period under review was 20,358 tons, being an increase of 98 per cent. over the preceding quinquennium. The chromite, which is exported from Karachi, is of high grade.

In Mysore State chromite occurs in the districts of Hassan, Mysore and Shimoga. It has been worked in the first two districts only, the production for 1907, the first year of work, being 11,029 tons. The output, which had sunk to *nil* in 1910, 1911 and 1912, rose like that of Baluchistan during the War and owing to the extraordinary vigour of Messrs. Oakley, Bowden and Company holding a prospecting license, reached the high figure of 33,740 tons, much of it high grade ore, in 1918. In 1919, 22,372 tons were raised, but the yields for these two years seems to have been but a flash in the pan as the above table will shew. The average annual output of Mysore for the quinquennial period was 13,035·2 tons, most of which was derived from the Hassan district.

Chromite seems to have been first found in Mysore State by Mr. H. K. Slater, who discovered a rock shewing grains of chromite in a talcose matrix near Harenhalli in the Shimoga district.[1] Even the richest specimens did not indicate more than 35 to 40 per cent. of Cr_2O_3.

A geological survey of the chromite area to the west of Chaibassa in Singhbhum, discovered by Mr. R. Saubolle in 1907, has shewn that the ore occurs as bed-like veins and as scattered granules in serpentinized saxonites and dunites forming laccolitic intrusions several hundred feet thick in Dharwar slates and slaty shales. As in Baluchistan the chromite is of primary (magmatic) origin and contemporaneous with the peridotites. The subsequent serpentinization of the peridotites has been accompanied by widespread silicification with production of marginal zones of chert. The ore-bearing horizon is unusually persistent over a considerable distance, but the total amount of ore does not appear to be large. As exported the ore carries 50 per cent. of Cr_2O_3 and upwards, but the possibility of concentrating ores of lower grade is worth consideration.

[1] *Rec. Mysore Geol Dept.* II, p. 129. *Rep. Chief Inspect. Mines, Mysore*, 1906-07, p. 36.

Coal.

[J. COGGIN BROWN.]

For the first time since the year 1882 the expansion in the coal-mining industry has been interrupted, the record production of 22,628,037 tons in 1919 falling by over 20 per cent. to 17,962,214 tons in 1920. The annual figures for production and value during the quinquennial period are shown in Table 6, and from them it is seen that the output for 1923 is still approximately 13·1 per cent. below that of 1919. Amongst the reasons which have been alleged to be responsible for the decline the following may be mentioned: reduction of the post-war demand, in the earlier part of the period; unremunerative selling prices; acute shortage of railway wagons for loading; inadequacy of the labour supply and decreased output per person employed for part of the time under review; the prolonged strike on the East Indian Railway in 1922; floods caused on the Jharia coal field by an exceptionally heavy monsoon in 1922; fires caused by spontaneous combustion necessitating the closing of mines towards the end of the period; and the importation of foreign coal in increasing quantities. In the cumulative effect of these adverse circumstances coupled with the world-wide depression in trade, the cause of the reduction of the coal output is explained.

Output.

Table 7 shows the average pit's mouth value per ton of the coal extracted from the mines in each province during the quinquennial period. The figures for the North-West Frontier Province and for Burma are not included as they are not complete for all the years; in any case, the amount of coal that has been produced in these provinces is negligible.

Prices.

It is necessary to point out that the values given in the table represent wholesale prices of all grades of coal at the pit's mouth, and that they are dependent on a combination of local circumstances which cannot be used as an indication of the actual value of the fuel in the open markets. For example, coal from Bengal and Bihar, which is ranked amongst the best grades in India, is shown as having a lower value than the poorer quality coals of some other provinces where the wages of labour and mining costs generally are higher.

In the last quinquennial review, it was pointed out that in 1917 all first class coal was requisitioned and controlled by Government and that prices were fixed by the Coal Controller. Although, except

for part of the year 1918, only first class coal was requisitioned, the control inevitably reacted on the price of second class grades, for, the

TABLE 6.—*Production and Value of Coal during the years 1919 to 1923.*

Year.	Quantity.	Total value at the mines.		Average value per ton at the mines.	
	Tons.	Rs.	£	Rs. A.	*s. d.*
1919 . .	22,628,037	10,11,92,564	8,799,353(*a*)	4 8	*7 10(a)*
1920 . .	17,962,214	9,29,78,532	9,297,853(*b*)	5 3	*10 4½(b)*
1921 . .	19,302,947	13,01,00,652	8,673,377(*c*)	6 12	*9 0(c)*
1922 . .	19,010,986	14,63,30,142	9,755,343(*c*)	7 11	*10 3(c)*
1923 . .	19,656,883	14,60,59,747	9,737,316(*c*)	7 7	*9 11(c)*

(*a*) Rupee = 1*s.* 8⅞*d.* (*b*) Rupee = 2 shillings. (*c*) Rupee = 1*s.* 4*d.*

TABLE 7.—*Average pit's mouth value (per ton) of coal extracted from the mines in each Province during the years 1919 to 1923.*

Province.	1919	1920	1921	1922	1923	Average.
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Assam . .	7 10 6	7 7 9	7 13 4	8 5 4	8 11 1	8 0 0
Baluchistan .	15 12 2	16 9 9	14 1 8	13 7 5	14 14 4	14 15 6
Bengal . .	5 0 1	6 5 5	7 11 8	9 10 1	9 1 9	7 9 0
Bihar & Orissa .	4 1 2	4 9 2	6 6 10	6 15 5	6 13 7	5 12 5
Central India .	3 9 7	4 4 10	5 11 6	5 13 6	5 13 0	5 0 11
Central Provinces.	5 7 0	5 13 3	7 0 0	7 10 7	6 10 7	6 8 3
Punjab . .	11 12 8	12 3 10	14 13 8	14 13 10	9 15 10	12 12 0
Rajputana .	6 9 0	7 7 1	8 13 4	7 2 2	6 13 9	7 5 10

better material being no longer procurable in the open market, its place was taken by the inferior, which being uncontrolled, frequently sold at higher prices than were being paid by the Controller for first class coal. During 1919 all coal of first class quality remained under requisition, but owing to the demand for post-war purposes being considerably reduced, good coal was available in large quantities for general purposes. Owing to shortage of railway rolling stock, despatches of poorer grades were very limited, but such coal as was supplied was sold at very high rates. On the 31st March 1920 the official requisition on coal was removed and prices improved very considerably towards the end of the year. The average price, f.o.r. at the mines, of the best quality of Bengal coal (Dishargarh) was Rs. 8-12-10 per ton for 1920 compared with Rs. 5-1-4 per ton in 1916, the year before the control was initiated. Throughout the year 1921, prices remained very high owing to the demand being far in excess of the supply, and very high rates were paid for odd wagons secured on public service. The average price for best Bengal coal, f.o.r. at the mines, for the year was Rs. 18-2-8 per ton. During 1922 the price of first class coal remained steady.

In the following table, the average value of the coal at the pit's mouth, obtained from both Bengal and Bihar & Orissa figures, is compared with the average declared export value per ton.

Year.	Declared export value per ton.		Value at the pit's mouth, per ton.	
	Rs.	A.	Rs.	A.
1919	11	14	4	1
1920	12	13	4	9
1921	13	15	6	7
1922	13	8	6	15
1923	17	2	6	14

TABLE 8.—*Production of Coal (including Lignite) in the four largest British Dependencies.*

Countries.	1917		1918		1919		1920		1921		1922	
	Long Tons	*Per cent. of British output.*	Long Tons	*Per cent. of British output.*	Long Tons	*Per cent. of British output.*	Long Tons	*Per cent. of British output.*	Long Tons	*Per cent. of British output.*	Long Tons	*Per cent. of British output.*
India . .	18,212,918	*5·99*	20,722,493	*7·00*	22,628,037	*7·86*	17,962,214	*6·20*	19,302,947	*8·69*	19,010,986	*5·61*
Australia. .	10,236,666	*3 36*	10,949,343	*3·69*	10,566,724	*3·66*	12,968,352	*4·49*	12,877,526	*5·80*	12,299,019	*3·63*
Canada . .	12,542,000	*4·12*	13,373,000	*4·51*	12,215,000	*4·24*	14,842,000	*5·14*	13,444,189	*6·06*	13,533,000	*4·00*
South Africa .	9,776,058	*3·21*	9,308,008	*3·14*	9,691,638	*3·37*	10,749,934	*3·72*	10,644,812	*4·79*	9,125,000	*2·69*
Total for British Empire.[1]	303,873,000	..	296,629,000	..	288,000,000	..	289,000,000	..	222,000,000	..	338,590,000	..

[1] Approximate.

Comparison of India with Australia, Canada and South Africa.

In Table 8, the coal outputs of the larger British dependencies are given from 1917, as the statistics of the last quinquennial review finish at 1916, up to the end of 1922, the last year for which figures are available at the time of writing. It will be seen that India still maintains her leading position in front of the other dependencies. In 1921, the production of this country in spite of the diminution of output from the record year of 1919, exceeded that of Australia by nearly 6½ millions, of Canada by more than 5¾ millions and of the Union of South Africa by over 8½ millions of tons. It is interesting to note also that India's share of the total output of the British Empire which rose from 3·65 per cent. during the period 1903-07, to 5·3 per cent. in 1913-16, was 6·9 per cent. in 1917-22.

Comparison of India with Japan.

Although the depressed condition of the coal trade has affected the production of coal in Japan as well as in India during the period 1919-23, the former country has now left India well behind in total output. At the same time, the Japanese imports of coal continue to increase steadily and in 1922 were over one million tons for the first time in her history. The quantity of coal retained for consumption in Japan is now very greatly in excess of the amount of coal consumed in India, and in 1922 totalled over 26 million tons. For the sake of comparison it is interesting to recall that in 1908 India retained more coal than Japan did, but from 1909 onwards Japan has always exceeded India. Moreover, a given consumption of coal in Japan registers a much greater proportional industrial activity than does the same consumption in India on account of the much smaller population of the former country. In pre-war years Japan was a serious competitor of India for the supply of coal to ports in the Eastern Seas, particularly in the case of Ceylon and the Straits Settlements. The disintegration of the Indian export trade has of course been to the advantage of Japan and although her exports to the Straits Settlements are not as large as they were in the previous period, she still maintains her predominant position in the market there. Considerable quantities of Japanese coals are also exported to French Indo-China where they are used for blending with the lower grade coals of local origin before briquetting.

The freight per ton of coal carried on Indian railways in 1922 was 2¾ pies per ton per mile, except in the case of coal despatched to

Howrah, in close proximity to Calcutta, where the rate comes to 4½ pies per mile. The average rate of freight for coal on Japanese railways was 6 pies per mile.[1]

TABLE 9.—*Comparison of Indian and Japanese Coal Statistics.*

Year.	Production.		Imports.		Exports.		Quantity retained for consumption in Japan.
	India.	Japan.	India (*a*)	Japan	India (*a*)	Japan.	
1885	1,294,221	1,294,000	790,930	12,876	750	191,802	1,115,074
1890	2,168,531	2,566,551	784,664	12,301	26,649	853,720	1,725,132
1895	3,540,019	4,733,861	761,996	68,931	81,126	1,376,068	3,426,724
1900	6,118,692	7,369,068	135,649	108,593	490,491	2,402,785	5,074,876
1905	8,417,739	11,407,799	197,784	329,495	783,051	2,507,527	9,229,767
1909	11,870,064	14,732,970	490,421	129,858	563,940	2,798,563	12,064,265
1913	16,208,009	20,973,384	644,934	567,502	759,210	3,808,394	17,732,492
1918	20,722,493	27,578,952	54,346	755,452	74,466	2,161,727	26,172,677
1919	22,628,037	30,767,537	48,675	688,402	508,635	1,968,543	29,487,396
1920	17,962,214	28,775,369	39,727	796,892	1,224,872	2,095,305	27,476,956
1921	19,302,947	26,220,617	1,090,749	777,255	277,852	2,387,709	24,610,163
1922	19,010,986	27,256,505	1,220,639	1,168,524	150,055	1,690,699	26,734,330

(*a*) Excludes Government Stores.

Relation of consumption to production.

The markets for Indian coal are confined to her home industries and to certain Indian ocean ports, where local manufacturing industries are not highly developed and for which India is not the sole source of supply In the period 1909-13, the average internal consumption was 93·9 per cent. with an average annual import of

[1] Report on the Production and Consumption of coal in India, 1922, issued by the Director General of Commercial Intelligence as Supplement to the "Indian Trade Journal," p. 7.

466,162 tons of foreign coal. The consumption for the next period 1914-18 rose to 96·9 per cent. with an average annual import figure of 148,522 tons. With the exception of the year 1920 when the percentage consumed fell to that of a decade age, the figures for the present period are well in advance of the earlier ones.

The actual average annual consumption since 1919 has been 19,882,616 tons, while the production during the same period has averaged 19,712,213. These figures again indicate, if such an indication be needed, that the expansion in the Indian coal trade is due

TABLE 10.—*Relation of Consumption to Production* (*a*).

Year.	Total consumption of coal in India.	Consumption of Indian coal in India.	
		Quantity.	*Percentage of Indian production.*
	Tons.	Tons.	
1919	22,168,495	22,118,893	*97·7*
1920	16,776,083	16,735,215	*93·2*
1921	20,122,242	19,025,453	*98·6*
1922	20,182,555	18,933,243	*99·6*
1923	20,163,705	19,520,292	*99·3*
Average .	*19,882,616*	*19,266,619*	*97·7*

(*a*) The consumption of coal is assumed to be production *plus* imports *minus* exports. In the exports and imports a ton of coke is taken to be equivalent to 2 tons of coal. The imports exclude Government stores.

to industrial developments in India herself. So interdependent are the two in fact that there are those who believe that the future expansion of the latter is controlled by the unrestricted growth of the former. Although it is admittedly approximate the following table giving an estimate of the total quantity of coal, both Indian and foreign, consumed during the year 1922 is not without interest.[1]

[1] From Report on the Production and Consumption of coal in India, 1922, issued by the Director General of Commercial Intelligence as Supplement to the "Indian Trade Journal," p. 5.

	Estimated Consumption.	*Per cent. of total.*
	Tons.	
Railways	6,186,000(*a*)	*30·8*
Admiralty and Royal Indian Marine	40,000	*0·2*
Bunker coal	796,000	*4·0*
Cotton mills	1,131,000	*5·6*
Jute mills	942,000	*4·7*
Iron industry (including engineering workshops)	2,415,000	*12·0*
Port Trusts	210,000	*0·1*
Inland steamers	582,000	*2·9*
Brick kilns, potteries, cement works, etc.	437,000	*2·2*
Tea gardens	204,000	*1·0*
Paper mills	147,000	*0·7*
Collieries and wastage	2,471,000	*12·3*
Other forms of industrial & domestic consumption	4,521,000(*b*)	*22·5*
	20,082,000	*100·0*

(*a*) Official year 1922-23.

(*b*) This figure appears high but it includes many classes of establishments and factories which are worked by steam power, such as cotton gins and presses, jute presses, rice and flour mills, dock yards, oil mills, water works, electric power stations, gas works, tramways, gold and other mines, sugar factories, lime kilns, breweries and distilleries, ice and aerated water factories, mints, municipal workshops, flour mills, woollen mills, chemical works, dye works, rope works, glass works, lac and indigo factories, etc. A certain amount of coke is used for domestic consumption and its use is extending owing to the growing scarcity and increasing cost of wood fuel.

TABLE 11.—*Coal consumed on Indian Railways during the years 1918-19 to 1922-23.*

Year.	Indian Coal.		Foreign Coal.		Total consumption.
	Quantity.	*Per cent. of total.*	Quantity.	*Per cent. of total.*	
	Tons.		Tons.		Tons.
1918-19	5,880,165	*100*	964	..	5,881,129
1919-20	6,055,492	*100*	860	..	6,056,352
1920-21	6,287,068	*100*	586	..	6,287,654
1921-22	5,478,902	*88·5*	710,066	*11·5*	6,188,968
1922-23	5,476,041	*88·5*	710,329	*11·5*	6,186,370
Average	*5,835,534*	*95·4*	*284,561*	*4·6*	6,120,095

Consumption of coal on Indian Railways.

The average annual consumption of coal by railways in India during the period under review was over 6 million tons compared with approximately 5¼ million tons during the preceding quinquennium and a little over 4 million tons in the period 1909-13. During the past five years the consumption of Indian coal on the railways has averaged 29·6 per cent. of the total Indian production, compared with 28·8 per cent. for the preceding quinquennium and 30 per cent. for the three similar periods before that.

Foreign coal was rapidly displaced by the Indian product after 1888, when it amounted to 31 per cent. of the total. During the years 1918-21, Indian collieries supplied all the coal used on the railways, but for the last two years there have been large imports of coal from abroad, amounting to 11·5 per cent. of the total in the years 1921-22 to 1922-23. Wood is still used extensively as a fuel on the South Indian, the Burma, the Madras and Southern Mahratta, the Rohilkhand and Kumaun, and the Bombay, Baroda and Central India Railways. On account of the abnormally high prices of coal, the regular use of oil fuel for locomotives is steadily increasing especially on certain sections of the Great Indian Peninsula and the North Western Railways.

Earnings of Railways from transport of coal.

The transport of coal forms an important item in the earnings of the Railway companies, especially of the East Indian and Bengal-Nagpur systems which serve the coalfields of Raniganj, Jharia, Bokaro and Giridih. Details are given in Table 12 which excludes coal carried by railways for their own consumption.

TABLE 12.—*Coal carried for the Public in India and for Foreign Railways during the years 1918-19 to 1922-23.*

Year.	Coal carried on Indian Railways.	Earnings of Railways from coal Traffic.
	Millions of Tons.	Rs. Million.
1918-19	23·25	88·04
1919-20	21·40	79·08
1920-21	21·86	82·14
1921-22	18·78	72·99
1922-23	20·37	85·30

Table 13 shows the relation between the imports of foreign coal and the exports of Indian coal for the past 15 years and brings out clearly the remarkable and unprecedented fluctuations that have

TABLE 13.—*Imports and Exports* of Coal during the years 1909 to 1923.*

Year.	Imports.	Exports.
	Tons.	Tons.
1909	490,421	563,940
1910	315,996	988,366
1911	318,669	862,177
1912	560,791	898,739
1913	644,934	759,155
1914	418,758	579,746
1915	190,654	753,042
1916	34,033	881,741
1917	44,818	408,117
1918	54,346	74,466
Average 1909-1918 . . .	*307,342*	*676,949*
1919	48,675	508,537
1920	39,727	1,224,758
1921	1,090,749	275,571
1922	1,220,639	77,111
1923	624,918	136,575
Average 1919-1923 . . .	*604,942*	*444,510*

taken place. These figures should be studied with those of production already given in Table 6. The average amounts imported and exported annually during the period 1919-1923 were 604,942 tons and 444,510 tons, respectively, compared with 148,522 tons and 539,422 tons for the period 1914-18. There was a particularly marked drop in exports in 1922 and a record import of nearly 1¼ million tons.

* Excluding bunker coal and Government stores, but including coke and patent fuel.

TABLE 14.—*Origin of Foreign Coal (a) imported into British India.*

YEAR.	United Kingdom.	Australia.	Union of South Africa.	Japan.	Portuguese East Africa.	Other Countries.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1919 .	5,643	3,329	18,089	927	16,880	3,807	**48,675**
1920 .	5,022	8,134	7,835	4,392	7,933	6,411	**39,727**
1921 .	441,305	111,384	306,968	68,071	156,555	6,466	**1,090,749**
1922 .	742,469	17,849	236,034	55,547	157,122	11,618	**1,220,639**
1923 .	131,739	59,380	281,793	4,660	115,942	31,404	**624,918**
Average.	*265,236*	*46,015*	*170,144*	*26,719*	*90,887*	*11,911*	**604,942**

Imports of foreign coal.

To compensate in some measure for the decline in the country's production, Indian railways and industries have been compelled to resort to the importation of foreign coal in very large quantities during the three years 1921-23. The sources of this coal are given in Table 14, from which it will be seen that the United Kingdom and South Africa figure very prominently in the list. The average annual imports for the quinquennial period 1919-23 totalled 604,942 tons as compared with 148,522 tons for the preceding period.

TABLE 15.—*Exports of Indian Coal (a).*

——	1919	1920	1921	1922	1923	*Average*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Aden	13,525	83,669	17,576	..	..	*22,654*
Ceylon	296,192	685,559	236,645	76,742	119,620	*282,951*
Java	17,196	16,083	..	50	100	*6,686*
Straits Settlements . .	116,304	228,355	11,373	..	15,888	*74,284*
Sumatra	41,756	69,473	6,251	..	..	*23,496*
Other Countries . . .	23,564	141,619 (b)	3,726	319	1,467	*34,139*
Total Exports .	**508,537**	**1,224,758**	**275,571**	**77,111**	**136,575**	*444,510*
Value in Rs.	60,38,110	1,57,13,040	38,47,395	10,62,433	23,41,960	*58,00,587*
Value in Sterling. .	£525,053 (£1 = Rs. 11·5)	£1,571,304 (£1 = Rs. 10)	£256,493 (£1 = Rs. 15)	£70,829 (£1 = Rs. 15)	£156,131 (£1 = Rs. 15)	*£515,962*

(a) Excluding Government stores but including coke and patent fuel.
(b) Includes 102,457 tons to Egypt.

In Table 15 the destination of Indian coal which is exported by sea can be seen for the years 1919 and 1920 and the prominent position occupied by Ceylon and the Straits Settlements is evident. In spite of the increased production in 1921, the domestic coal situation became so acute that it was found necessary early in the year to prohibit the export of coal to foreign ports. Exports in 1922 were so restricted that they were in the proportion of only 1 ton to about 250 tons produced. In this year nearly the whole quantity (99·5 per cent.) was destined for Ceylon and no coal was exported to the Straits Settlements owing to the continuation of the prohibitory order. Almost all the coal shipped from India as private merchandise is sent from Calcutta.

Exports of Indian coal.

During the year 1919 the coal control was gradually relaxed and all restrictions on the output of collieries were removed in January. The output of all collieries producing first class coal remained under requisition until the end of March, up to which date the shipment of coal from Calcutta and the bunkering of ships at that port were controlled by Government. At the end of the year the special indent system was abolished and it was intended that the pre-war system of allotment of wagons to the collieries should be reverted to; unfortunately, however, the wagon supply proved unequal to the demand and this could not be done. No change was made in the system in 1921.

The coal control.

In 1922 a prolonged strike on the East Indian Railway, necessitated the institution of a more rigorous control again in order to ensure the distribution of supplies to consumers in need throughout the country. In July 1922 there was a conference in Calcutta to arrive at some settlement of the vexed question of coal transportation, and a scheme was drawn up whereby the Coal Transportation Officer was assisted by an Advisory Committee appointed by the Government of India from the various Associations interested.

Tables 16 and 17 show how India has lost ground in her two chief markets. It has been stated in an earlier report that the variations in the share which India takes in these markets has never been of much value as an index to the growth of the industry. This is not entirely true with reference to the period under review, for, although the collieries have often been barely able to meet the domestic demand and Indian consumers have complained no less than outside customers

Indian coal abroad.

TABLE 16.—*Foreign Coal Imports of Ceylon for the years 1919 to 1923.*

ORIGIN OF THE COAL.	1919.	1920.	1921.	1922.	1923.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
United Kingdom .	2,104	6,165	129,568	243,857	166,968	*109,732*
British India . .	488,696	640,742	201,479	72,858	124,414	*305,638*
Japan . . .	23,602	8,928	28,313	5,815	80	*13,348*
Other Countries .	171,675	49,358	281,601	262,527	253,086	*203,649*
TOTAL Imports .	686,077	705,193	640,961	585,057	544,548	*632,367*

TABLE 17.—*Foreign Coal Imports of the Straits Settlements for the years 1919 to 1923.*

ORIGIN OF THE COAL.	1919.	1920.	1921.	1922.	1923.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
United Kingdom .	693	151	10,364	90,583	33,888	*27,136*
British India . .	87,066	188,432	12,493	..	21,984	*61,995*
Australia . . .	64,543	138,472	92,941	67,277	34,965	*79,640*
Japan . . .	271,326	341,195	340,007	226,646	176,692	*271,173*
Other Countries .	79,413	58,451	85,255	199,908	366,223	*157,850*
TOTAL Imports	503,041	726,701	541,060	584,414	633,752	*597,794*

of the quantities of low-grade fuel forced on them during a boom, there can be no doubt that a healthy export trade may be a sure indication of satisfactory internal conditions, betokening alike the existence of an efficient transport system and the satisfaction of the demands of the home consumer first. It is to be hoped that the removal of the restrictions on the export of coal, the grant of railway rebates, and the opening up of new coalfields in India, will help this country to recover the position she formerly held in these important outside markets during the near future.

TABLE 18.—*Quantity of coal, coke and patent fuel, exported from Calcutta to Indian Ports during the years 1919 to 1923.*

PORTS.	1919.	1920.	1921.	1922.	1923.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Bombay . . .	25,458	436,852	610,181	82,156	100,755	*251,080*
Sind . . .	..	75,990	115,341	28,794	62,095	*(a)56,414*
Madras ; chief port .	22,354	105,358	197,130	180,905	194,602	*140,070*
Madras ; other ports.	8,899	25,387	178,318	175,856	16,086	*80,909*
Burma ; chief port .	122,769	359,864	417,120	308,727	459,353	*333,567*
Burma ; other ports	8,674	9,462	10,788	8,956	13,164	*10,209*
Bihar and Orissa .	74	318	418	178	287	*255*
Bengal ; all ports .	55	17,099	34,891	22,199	9,898	*16,828*
Pondicherry . .	1,671	..	600	..	..	*(a)454*
Kathiawar ; Dwarka	..	..	29,833	..	..	*(a)5,967*
Kathiawar ; Porebunder.	..	..	1,822	..	..	*(a)364*
TOTAL .	189,954	1,030,330	1,596,442	807,771	856,240	*898,147*

(*a*) Average of five years.

The average quantity of coal shipped annually from Calcutta to other Indian ports is shown in Table 18 which indicates that there has been small improvement in coastal trade over that of the previous quinquennium.

Calcutta exports.

TABLE 19.—*Output of Indian Coal by Provinces for the years 1919 to 1923.*

Province.	1919.	1920.	1921.	1922.	1923.	Total.
Assam	291,734	325,535	312,465	348,103	326,149	1,603.986
Baluchistan . . .	34,328	33,941	54,627	60,135	42,562	225,593
Bengal	5,777,632	4,207,452	4,259,642	4,328,986	4,621,578	23.195.290
Bihar and Orissa . .	15,119,812	11,975,656	12,990,481	12,711,328	13,212,250	66,009,527
Burma	1,500	..	300	172	1,271	3,243
Central India . .	182,141	158,051	192,034	161,231	175,950	869,407
Central Provinces . .	497,021	491,205	712,914	675,916	548 074	2 925,130
Hyderabad . . .	662,196	694,080	688,721	642,880	658,429	3,346.306
North-West Frontier Province.	20	..	..	..	..	20
Punjab	46,893	58,078	67,242	67,180	63,501	302,894
Rajputana (Bikanir) .	14,760	18,216	24,521	15,055	7,119	79 671
TOTAL .	22,628,037	17,962,214	19,302,947	19,010,986	19,656 883	98.561,067

Table 19 shows the provincial production for the years 1919 to 1923. The Gondwana coalfields of Bengal and Bihar have decreased their output from over 20,800,000 tons in 1919 to 17,800,000 tons in 1923. Assam has steadily increased from over 291,000 tons in 1919 to 348,000 tons in 1922. It is to be regretted that the distance of the Assamese coalfields from the leading industrial centres and the seaports of India, prohibits more use being made of these high class coals of which such large reserves exist. The Baluchistan output has averaged 45,000 tons for the period, compared with under 44,000 tons per annum for the preceding one. For the last twenty years there has been little pronounced change in the coal production of this province. The insignificant quantities of coal reported from Burma represent small parcels removed during prospecting operations for experimental purposes. The production recorded for Central India is nearly all due to the Umaria collieries of the Rewah State, but from 1921 the Sonagpur coalfield commenced to add a small quota. There has been a large and regular increase in the output of coal from the

Provincial Production.

Central Provinces throughout the last decade, due to increasing production of the Mohpani field in the Narsinghpur district and more extended developments in those of the Chhindwara (Pench Valley) and Chanda (Wardha Valley) fields. Small amounts of coal are also now being produced from non-Act mines in the Betul (Shahpur) district. It is anticipated that the figures for the Central Provinces will continue to rise in the coming period. The production recorded for Hyderabad is due almost entirely to the Singareni mines which have continued practically at the high level attained during the war. Small amounts were also won from the Sasti mine which is really a portion of the Ballarpur field lying in Hyderabad territory.

The output of Tertiary coal from the Salt Range mines of the Punjab attained the record of 67,242 tons in 1921. The Rajputana production is that from the Palana colliery in Bikanir State and, although not so large as it has been in the past, shows some improvement over the last period.

Geological Relations of Indian Coals.[1]

The Gondwana System.

The formation from which 98 per cent. of the coal supplies of India is obtained was named the Gondwana system by H. B. Medlicott in 1872.[2] It is composed of sandstones conglomerates and shales, formed typically in fresh water and probably mainly in rivers.

The lowest division of the system is known as the Talchir series and derives its name from the small State of the same name in Orissa where the rocks were first described in detail and separated from the overlying Damuda series. The beds of this series are of small thickness; but they are known, and, from their peculiar features easily recognised, in most of the coalfields. They include boulder-beds supposed to be due to glacial action, and are thus regarded as similar in origin, probably also corresponding in geological age, to the Dwyka formation which lies at the base of the similar coal-bearing Karoo system in South Africa.

[1] See also V. Ball and R. R. Simpson; The coalfields of India, *Mem. Geol. Surv. Ind.*, XLI, pt. 1 (1913).

[2] F. Stoliczka *Rec. Geol. Surv. Ind.* IX, p. 28 (1876); and *cf.*, *Rec. Geol. Surv. Ind*, XIV, pt. II (1881).

The only part of the Gondwana system which is important from the coal-producing point of view is that distinguished as the Damuda series,[1] from its development in the valley of the Damuda river. In the Raniganj and Jharia fields this series can be subdivided into three stages, of which that distinguished as the Barakar below, and that known as the Raniganj stage above the Ironstone Shales, both include valuable coal-seams. The Raniganj stage produces the principal part of the supplies obtained from the Raniganj field, but seams in this stage of the Jharia field are generally thinner and poorer than those in the Barakar stage.

Age of the Lower Gondwana coal measures.

Until the end of the year 1921 when marine fossils were discovered in association with beds usually ascribed to the Talchir stage at Umaria in Central India, not a single instance of the occurrence of a marine deposit of later age than the Vindhyans had been found on the Peninsula, if we except the coastal fringes and a tract of country stretching from Indore to Kathiawar and Kachh. It was therefore impossible for the older geologists to determine with any precision the age of the coal measures with reference to the standard stratigraphical scale in Europe.

The geologists who first separated the Talchirs from the overlying strata of the Gondwanas regarded them on slender indirect evidence as probably not more recent than Permian in age.[2] On account of the affinities of the plant remains in the Lower Gondwanas, they were regarded as Triassic, while the Rajmahal beds in the Upper Gondwanas were considered to be Jurassic.[3] A reconsideration of the fossil evidence and comparison with similar beds associated with marine formations in Australia tended to confirm the earlier conclusions regarding the Palæozoic age of the Lower Gondwanas.[4] The discovery of typical Lower Gondwana plant remains embedded in marine formations in Kashmir, where they were deposited probably near the mouth of one of the great rivers flowing from Gondwanaland into the great ocean then covering the area now occupied by Central Asia, confirms the conclusion regarding the Palæozoic age of the Lower Gondwanas: these Gondwana plants have been found in beds that are certainly not younger than

[1] T. Oldham, *Journ. As. Soc. Bengal,* XXV, p. 253 (1856).

[2] W. T. and H. F. Blanford and W. Theobald; *Mem. Geol. Surv. Ind.,* I., p. 82 (1856).

[3] O. Feistmantel; *Rec. Geol. Surv. Ind.,* IX, p. 79 (1876).

[4] See recapitulation by W. T. Blanford; *Rec. Geol. Surv. Ind.,* IX, pp. 79-85 (1876).

Upper Carboniferous.[1] Although the marine fossils found at Umaria are not of great assistance in determining the precise age of this horizon they are typical Carboniferous forms and tend to confirm the conclusions already arrived at. As the Umaria fossil bed is followed immediately by fresh-water coal-bearing Barakar rocks it is evident that the Talchir ocean quickly retreated to the north towards the end of Talchir times.

From all the evidence available therefore it appears that the Indian coal measures are not much younger than, and may possibly be of the same age as those of Europe.

Although there are coal-seams in the Jurassic rocks of Kachh and in the Cretaceous beds of Assam, all the coal being worked outside the Gondwana fields is of Tertiary age.

Eocene coal: Palana.

At Palana in the Bikanir State, Rajputana, a lignitic coal containing small nodules of resin lies immediately underneath Nummulitic limestones[2], from which characteristic Lutetian (middle Eocene) fossils have been obtained.[3]

Tertiary coal in Assam.

Coal of the same age is being worked in the Punjab and Baluchistan, while some of that worked on a small scale in the Khasi and Jaintia Hills of Assam is also associated with Nummulitic rocks. The thick seams of the Lakhimpur district, which yield much of the coal now mined in Assam, belong to a series of beds whose age is not determinable by direct evidence, as they have not been found in contact with any fossiliferous marine formations. The same series yields the petroleum of the Digboi area, and because of this circumstance together with the fact that the overlying sandstones resemble the Pliocene Irrawadi series overlying the Miocene oil-bearing strata in Upper Burma, there is a temptation naturally to regard the Lakhimpur coal and associated petroliferous beds as Miocene in age.[4]

Some of the small coal basins on the Assam plateau are said to be of Cretaceous age, the coal in them being always characterised by the presence of lumps of fossil resin like those found in the Palana lignite.

[1] H. H. Hayden, *Rec. Geol. Surv. Ind.*, XXXVI, p. 38 (1907); C. S. Middlemiss *Ibid*, XXXVII, p. 286 (1909).
[2] T. D. LaTouche; *Rec. Geol. Surv. Ind.*, XXX, pp. 122-125 (1897).
[3] E. Vredenburg; *Rec. Geol. Surv. Ind.*, XXXVI, p. 314 (1907).
[4] E. H. Pascoe; *Mem., Geol. Surv. Ind.*, XL., p. 279.

TABLE 20.—*Origin of Indian Coal raised during the years 1919 to 1923.*

	FROM GONDWANA STRATA.		FROM TERTIARY STRATA.		Total production.
	Tons.	Per cent. of total.	Tons.	Per cent. of total.	Tons.
1919 . .	22,238,802	*98·28*	389,235	*1.72*	**22,628,037**
1920 . .	17,526,444	*97·58*	435,770	*2·42*	**17,962,214**
1921 . .	18,844,092	*97·62*	458,855	*2·38*	**19,302,947**
1922 . .	18,520,513	*97·43*	490,473	*2·57*	**19,010,986**
1923 . .	19,217,176	*97·77*	439,707	*2·23*	**19,656,883**
Average .	*19,269,405*	*97·74*	*442,808*	*2·26*	**19,712,213**

Table 20 shows the origin of the coal produced during the years 1919-1923. The output from the Gondwana coalfields in the period 1904-08 averaged 95·85 per cent., in 1909-13 97·03 per cent., and in 1914-18 97·70 per cent. of the total. The relative position occupied by the Gondwana and Tertiary coalfields during the previous quinquennium has thus been more or less maintained during the one under consideration with average percentages of 97·74 and 2·26.

Geological origin of the coal.

The highest percentage output reached by the Gondwana coalfields during the period was in the record year of 1919 when they contributed no less than 98·28 per cent. of the Indian total. On this occasion, as in the past, the high figure was due to great mining activity in Bengal and Bihar and Orissa and especially to the intensive exploitation of the Jharia coalfield of the latter province.

The Gondwana coalfields

It is interesting to recall that in 1903, when the first of this series of reviews was issued, the Raniganj field still occupied the first place on the list of India's producing fields, a position maintained until 1905. In 1906, however, Jharia outstripped Raniganj, and in subsequent years steadily increased its lead. For some years now this field has regularly produced more than half the coal raised in India. The figures of production of all the Gondwana coalfields are given in Table 21.

TABLE 21.—*Output of Gondwana Coalfields for the years 1919 to 1923.*

	1919.		1920.		1921.		1922.		1923	
	Tons.	Per cent of Indian Total.	Tons.	Per cent. of Indian Total.	Tons.	Per cent. of Indian Total.	Tons.	Per cent. of Indian Total.	Tons.	Per cent. of Indian Total.
Bengal, Bihar and Orissa—										
Bokaro	722,682	3·19	857,522	4·78	929,143	4·81	1,037,171	5·46	1,060,366	5·39
Daltonganj	63,250	0·28	39,113	0·22	36,590	0·19	31,933	0·17	11,815	0·06
Giridih	950,045	4·20	821,293	4·63	818,580	4·24	659,101	3·47	713,598	3·58
Jainti	152,941	0·69	118,651	0·66	105,652	0·55	96,612	0·51	82,166	0·42
Jharia	12,145,917	53·68	9,294,040	51·74	10,068,856	52·16	9,936,299	52·27	10,346,015	52·63
Rajmahal Hills	1,909	..	960	..	2,170	0·01	2,801	0·01	2,635	0·01
Ramgarh	..	..	6,863	0·04	..	..	4,565	0·02	4,197	0·02
Rampur (Raigarh-Hingir).	45,574	0·20	36,987	0·21	77,277	0·40	68,618	0·36	50,796	0·26
Raniganj	6,815,126	30·11	4,997,679	27·82	5,211,855	27·00	5,203,214	27·37	5,557,424	28·28
Talchir	..	..	..	..	..	..	..	..	4,816	0·02
Burma—										
Loi-an (Kalaw)	..	..	..	..	300	..	172	..	895	0·01
Central India—										
Sohagpur	..	..	..	..	37,060	0·19	42,693	0·22	80,125	0·41
Umaria	182,141	0·80	158,051	0·88	154,974	0·80	118,538	0·62	95,825	0·49
Central Provinces—										
Ballarpur	126,366	0·56	128,162	0·71	171,425	0·89	132,680	0·70	112,362	0·57
Mohpani	85,299	0·38	83,335	0·47	89,623	0·47	84,996	0·45	87,387	0·44
Pench Valley	285,356	1·26	279,483	1·56	449,311	2·33	453,484	2·39	346,094	1·76
Shahpur	..	..	..	..	210	..	1,069	0·01	2,063	0·01
Yeotmal	..	..	225	..	2,345	0·01	3,687	0·02	168	..
Hyderabad—										
Sasti	..	..	27,745	0·15	42,674	0·22	38,522	0·20	29,204	0·20
Singareni	662,196	2·93	666,335	3·71	646,047	3·35	604,358	3·18	629,225	3·21
TOTAL Gondwana beds	**22,238,802**	98·28	**17,526,444**	97·58	**18,844,092**	97·62	**18,520,513**	97·43	**19,217,176**	97·97

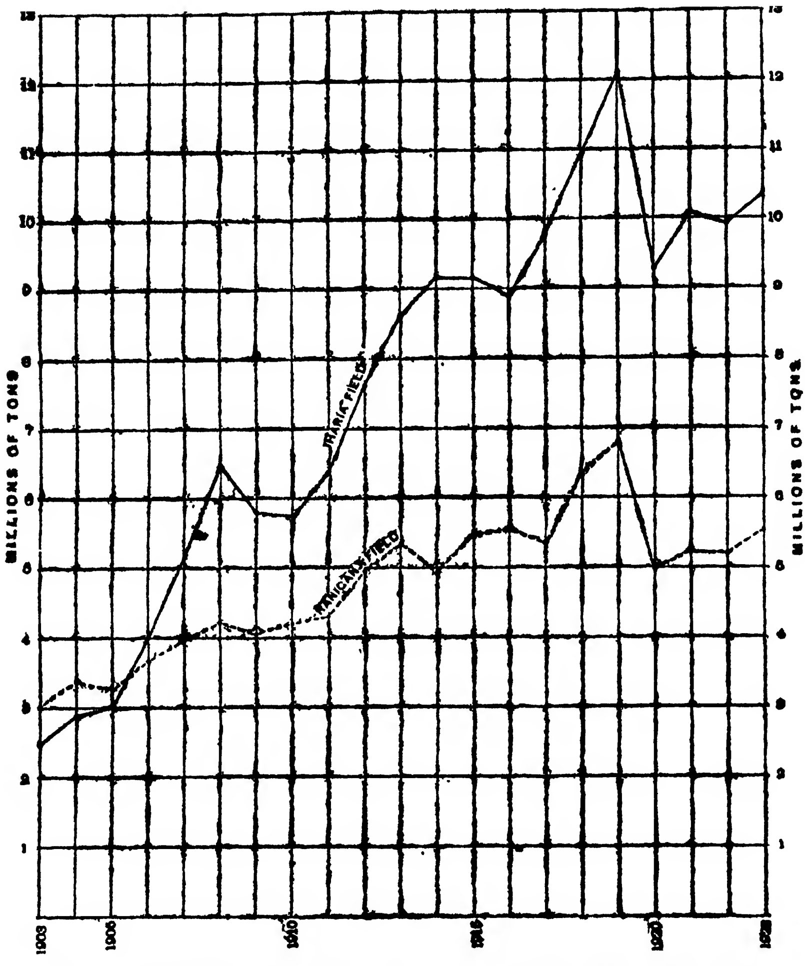

FIG. 8.—*Production of coal in the Raniganj and Jharia fields, 1903-1923.*

Distribution of the Gondwana fields.

The Gondwana coals have been preserved on the eastern part of the Peninsula by being faulted down into the Archæan basement complex; but either the faulting or the softness of the Gondwana rocks has determined the direction of the Damuda, Mahanadi, and Godavari valleys in which the principal fields are found. In the Central Provinces the Gondwana rocks form the Mahadeva (or

Mahadeo) Hills, a portion of the Satpura hill-range, which stands up above the general peneplain of the Peninsula.

The fields which have been worked to an appreciable extent include Raniganj and Jharia in the Damuda valley; the Giridih field occurring as a small isolated patch to the north of the Damuda valley; the Daltonganj field, further west, in the Palamau district; the Singareni, Ballarpur, and Warora fields in the Godavari valley; the Mohpani and Pench Valley fields lying respectively at the northern and southern fringes of the Satpura Range. Before the great depressions now occupied by the Indus, Ganges and Brahmaputra were formed, the Gondwanas probably stretched in great sheets of sandstone, shale and coal as far north as the area now occupied by the Outer Himalaya, and fragments of the strata caught up in the Himalayan folds are now preserved near Darjeeling, in Bhutan, and in North Assam. The coal in these extra-Peninsular patches of Gondwana rocks has been greatly damaged by crushing.

Boring for coal at Bhusawal.

The north-western ends of the Godavari and Mahanadi belts of coalfields have been overwhelmed by the great sheets of Deccan Trap, and no one knows, consequently, how much coal lies hidden under this mantle in the Central Provinces and Berar. During the period under review a deep boring was undertaken by the Great Indian Peninsula Railway Company at Bhusawal, East Khandesh district, Bombay, in search of possible coalfields below the Deccan Trap. By the end of 1922 this had reached a depth of 1,217 feet without penetrating the trap. Later, the boring was abandoned. The occurrence of the trap flows at considerable depths below sea level have proved that these rocks, at any rate in the neighbourhood of Bhusawal, have been faulted down at least several hundreds and possibly over a thousand feet, which introduces factors of quite uncertain magnitude into calculations of the thickness of trap to be pierced before the underlying rocks are likely to be encountered.

Raniganj field.

The Raniganj field covers an area of about 500 square miles, most of it within the civil district of Burdwan, but stretching also across the boundaries into Bankura, Manbhum, and the Santhal Parganas. A colliery was opened in 1774 at Aetma on the Barakar river, but the coal met with an unfavourable reception in Calcutta and the enterprise was abandoned. The first shafts were sunk at Raniganj about 1815 by a Calcutta mill-owner and the first survey of the field was made

by Homfray in 1842. The field was surveyed in 1858-60 by W. T. Blanford, and his map, published on a scale of one inch to a mile,[1] has been the recognised guide for colliery managers ever since. Additional details regarding seams discovered during subsequent mining operations have been added by Dr. W. Saise and Mr. G. A. Stonier to a map published by the Colliery Guardian.[2] A few years ago a Committee of the Mining and Geological Institute of India was formed to undertake the revision of the geological map on a scale of four inches to a mile, and Mr. H. Walker of the Geological Survey was placed on special duty in order to compile the results obtainable from the mine-plans. Thanks to the assistance given by Mr. R. R. Simpson, Inspector of Mines and to the willing co-operation of managing agents and colliery managers, the work was completed and the map published by the Mining and Geological Institute, which body has also completed a similar task in connection with the Jharia field.

The subdivisions of the Gondwanas represented on the field are :

3. Panchet.
2. Damuda :—
   c. Raniganj stage.
   b. Ironstone Shales.
   a. Barakar stage.
1. Talchir.

There is a general dip to the south and south-east throughout the field, and consequently the Talchirs are exposed as a band along the northern margin, succeeded by the younger formations towards the south. As the beds dipping to the south-east are overlapped by the alluvium of the Damuda valley, the distance to which the coal-bearing rocks extend towards Burdwan and Calcutta is unknown. In order to test the field in this direction a boring was put down by the East Indian Railway Company in the years 1903 to 1906 at Durgapur, 16 miles south-east of Raniganj, but to the depth of 3,000 feet the only rocks penetrated were those of the Panchet series and perhaps the upper part of the Raniganj stage. At this point, therefore, the coal-seams are buried to a greater depth than 3,000 feet. As the Damuda river stretches away to the south-east in an almost straight line for a distance of about 45 miles beyond the Raniganj field, and thus runs approximately parallel to some great faults within the field,

[1] See *Mem. Geol. Surv. Ind.*, III, Part I.
[2] Supplement; Feb. 10th 1905, p. 21.

it is possible that its alignment is determined by a great dip-fault, and the Gondwana strata possibly continue along the left bank of the river far beyond the visible limits of the field. Although the Durgapur boring shows that the coal-seams are at that point more than 3,000 feet below the surface, it is quite possible that the depressing effects of the general south-easterly dip may be neutralised by strike faults. Whether the coal measures are brought up in this way to within workable distance of the surface towards the south-east, or whether they are now hopelessly beyond reach, (if they ever were developed in this area), can only be determined by trial borings to the south-east of Durgapur. So long as there are abundant supplies nearer the surface in the Raniganj and Jharia fields, it will be to no one's financial advantage to risk the money required to test this interesting question.

The information at present available for publication regarding the quality of the coal being worked in the Raniganj field is comparatively limited, for the correlation of the various seams being worked in the different collieries is still doubtful. We are indebted to Dr. W. Saise for a series of essays published in 1904.[1] These shew the following extremes and averages:—

TABLE 22.—*Assays of Coal from the Raniganj Field (W. Saise).*

—		Moisture.	Ash.	Volatile matter.	Fixed carbon.
RANIGANJ (Upper Seams).	Highest . .	9·05	22·67	38·53	60·50
	Lowest . . .	4·60	8·00	26·40	32·40
	Average of 11 assays.	*6·86*	*14·93*	*32·22*	*45·99*
RANIGANJ (Lower Seams).	Highest . .	6·20	22·50	38·25	61·00
	Lowest . . .	1·50	8·84	27·00	46·00
	Average of 28 assays.	*3·81*	*13·54*	*31·40*	*51·25*
BARAKAR SEAMS	Highest . .	1·50	25·00	29·25	61·00
	Lowest . . .	0·50	11·00	23·75	49·00
	Average of 8 assays .	*1·00*	*17·00*	*26·75*	*55·25*

[1] *Rec. Geol. Surv. Ind.*, XXXI, p. 104.

With variations so wide among the samples these assays are too few to give reliable averages; but they show that the older Barakar seams differ consistently from those of the Raniganj stage in containing less moisture and generally also by having a smaller percentage of volatile hydrocarbons. This tendency was confirmed by the work of Lieutenant-Colonel F. C. Cunninghame Hughes who investigated the composition and calorific value of a number of samples from various Bengal and Bihar coalfields.[1] His results for the Raniganj field are summarised below [2] :—

—	Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Calorific value (in calories).
Raniganj or Upper Measures (average of 22 samples).	4·76	32·16	53·42	9·66	6,767
Barakar or Lower Measures (average of 8 samples).	1·65	24·76	64·05	9·54	7,348

Similar differences have been observed in the coal-seams of the Jharia field. The higher seams of the Raniganj stage also differ from those below by containing generally more moisture and volatile matter with less fixed carbon.

During 1922, a few assays of coals from the Raniganj field were made in the laboratory of the Geological Survey of India by Mr. W. Randall, with the following results :—

	Fixed carbon.	Volatile matter.	Moisture.	Ash.
Raniganj or Upper Measures (average of 3 samples).	46·3	32·4	3·9	17·4
Barakar or Lower Measures (average of 3 samples).	57·1	26·5	0·83	15·6

Although these assays are too few in number to warrant any far-reaching conclusions, at the same time, such as they are, they

[1] *Trans. Min. Geol. Inst. of India*, V. I. 114 (1910).
[2] R. R. Simpson, *Mem. Geol. Surv. Ind.*, LXI, p. 490, (1913).

confirm the general differences in the composition of the coals in the Raniganj and Barakar Measures, indicated above.

Jharia field.

The Jharia field lies 16 miles to the west of Raniganj, and although coal was known to occur here before 1777, the development of the industry in this, the largest producing coal-field of the Indian Empire, may be said to date from the opening of the East Indian Railway from Barakar to Dhanbad and Katras in 1894 and from Kasunda to Pathardih in 1895. The rapid increase in production from 126,686 tons in 1894 to over 10 millions of tons, the average for the quinquennial period under review, was rendered possible by the greatly improved facilities for transport brought about by the entrance of the Bengal Nagpur Railway into the field in 1904, the doubling of the East Indian Railway line from Barakar to Dhanbad, the opening of the same railway's Grand Chord line from Dhanbad to Gomoh, and the construction of numerous sidings in the coalfields.

In this coalfield the only Gondwana formations that remain are the Talchirs and the three divisions of the Damuda series—the Barakar, Ironstone Shales, and Raniganj. In the Barakar beds, which form a crescent-shaped outcrop along the northern and eastern boundaries of the field, 18 seams of coal, varying from a few inches to 100 feet or so in thickness, have been found. They are numbered from the margin inwards, from 1 to 18. The nine lowest are, as a rule, of poor quality, and work is confined chiefly to Numbers 10 to 18. The thinner and poorer seams of the Raniganj series were not mined before the coal "boom" of 1906-08.

Composition of Jharia coals.

During 1903 a number of coal samples from the Barakar seams were taken by Professor H. Louis and Mr. E. P. Martin at the working faces in some of the leading mines. The average of fifteen assays made on these samples was as follows:—

	Per cent.
Fixed Carbon	63·50
Volatile Matter	21·31
Moisture	0·90
Ash	14·29

Ten of these were tested for sulphur and were found to contain on an average 0·57 per cent. while the same ten samples showed an average evaporative power of 12·82 lbs. of water per lb. of coal.

In 1909, assays were made by Lieutenant-Colonel F. Cunninghame Hughes which are summarised below.

—	Fixed carbon, per cent.	Volatile matter, per cent.	Moisture, per cent.	Ash, per cent.	Calorific value (in calories).
Raniganj or Upper Measures (2 samples).	57·26	30·61	1·68	10·45	7,195
Barakar or Lower Measures (22 samples).	63·77	23·21	1·25	11·78	7,197

Recently a large number of samples of Jharia coals have been analysed in the laboratory of the Geological Survey of India by Mr. W. Randall in connection with an investigation into the behaviour of Indian coals towards froth flotation. In the case of seams Numbers 10 to 18, the ash percentages reported varied from 12·4 to 23·6, moisture from 0·4 to 1·4, volatile matter from 18·5 to 27·9 and fixed carbon from 57·0 to 59·6 per cent. respectively.

The Jharia field, like those of Raniganj and Giridih, is traversed by trap-dykes, the most destructive being a peculiar form of mica-peridotite[1] which spreads out as sheets in the coal-seams, destroying large quantities of valuable coal. The seams known as 14 and 15, which otherwise include a high quality of coal, are especially damaged by trap intrusions in the centre and east of the field. Small faults occur in most parts of the field, but generally in the north and east there is little disturbance and the seams, which dip inwards at gentle angles to the south and west, can be followed with air confidence; the south-east corner however, is considerably faulted, the seams generally dip at greater angles, and the correlation of the seams worked in this area with those numbered in the rest of the field is often a matter of conjecture.

The field was first mapped and described by the late T. W. H. Hughes [*Mem. Geol. Surv. Ind.*, Vol. V, part 3 (1866)]. Certain additions and corrections were made after further examination by T. H. Ward in 1890 (*Rec. Geol. Surv. Ind.*, Vol. XXV, page 110), and Mr Ward's map, with further additions by G. A. Stonier, was republished by the *Colliery Guardian* in 1904 (Supplement, September 16th, page 5).

[1] T. H Holland, *Rec. Geol. Surv. Ind*, XXVII, p. 129 (1894).

A large-scale map of the Jharia field on a scale of 4 inches=1 mile has been published by the Mining and Geological Institute of India. The completion of this undertaking was due largely to the efforts of Mr. R. R. Simpson, Chief Inspector of Mines. The geology was revised by Mr. G. de P. Cotter of the Geological Survey of India. It is proposed in the near future to re-survey the field again on special topographical maps which are now being made for the purpose as the incompleteness of the old survey sheets has rendered proper correlation of the seams, and consequently accurate estimation of reserves, impossible.

Immediately west of Jharia, on the other side of the Jamuni river lies the western end of the Jharia field, known as Bokaro-Jharia. To the west of this again the Bokaro field is situated. This field has an area of 220 square miles and the extension of the Bengal Nagpur Railway to it has led to its rapid exploitation. It is divided into two sections, East Bokaro and West Bokaro, the separating barrier being Lugu Hill which consists of a large mass of Panchet rocks.

The Bokaro Field.[1]

In the eastern area mining operations are in active progress and on the completion of the railway extension from Bermo to Hesla, which it is estimated shou'd be by the end of 1924, this field will at once be in a position to despatch two millions of tons of coal per annum and rapidly increasing quantities thereafter. In 1923, the output from this field, just over one million tons, was derived from the three collieries which were just commencing operations at the time of writing the last review, but which are now practically completely developed. These are the Joint East Indian and Bengal Nagpur Railways' colliery, the Kargali colliery of the Great Indian Peninsula Railway and the Dhori colliery opened by the Bokaro and Ramgarh Limited. Two areas known as Jarangdih and Jaridih are being developed jointly by the Bombay, Baroda and Central India and the Madras and Southern Mahratta Railways, respectively, while the East Indian and Bengal-Nagpur Railways are opening out another area in Sawang.

The same seam of coal, the Kargali, is being and will be worked at all the collieries mentioned. At Dhori colliery the seam occurs in two sections, each about 37 feet in thickness and divided by about 40 feet of hard sandstone but, 2,000 feet to the dip, borings have proved

[1] Based on information kindly supplied by Mr. C. Whitworth, Chief Mining Engineer to the Railway Board.

the absence of the band and a thickness of coal of over 70 feet. At the Kargali colliery immediately to the west, the sandstone band is only about 15 feet in thickness, whilst at the adjoining mine worked by the East Indian and Bengal Nagpur Railways, it has entirely disappeared and the seam has increased in thickness to just over 100 feet. Further still to the west, across the Koonar river, at the Jarangdih colliery, the Kargali seam increases to the enormous thickness of 126 feet of clean coal and is found at depths varying from 450 feet to 1,800 feet below the surface. In addition to this two other seams have been proved in this district, one 12 feet and the other 6 feet in thickness. At the Sawang property, already mentioned, which is situated some three miles to the West of Jarangdih, the Kargali seam has thinned down to 10 feet.

In the West Bokaro field which is about 12 miles due west of the East Bokaro, several seams of workable thickness are now known to occur. The East Indian and Bengal Nagpur Railways have taken up two areas here but development has not yet started. Bokaro and Ramgarh Limited are carrying out extensive operations throughout the field. It should be pointed out that much of the coal from Bokaro possesses good coking qualities.

Ramgarh.

The small field of Ramgarh, with an area of 40 square miles, lies about 5 miles south of Bokaro. It is traversed by the Damuda river, in the bed of which the coal crops out at numerous places.

North and South Karanpura.[1]

The extensive coalfields of North and South Karanpura, with areas of 472 and 72 square miles respectively, lie at the base of the southern scarp of the Hazaribagh table-land, from one to two miles west of Bokaro. The Karanpura Development Company hold a concession over the whole of the two coalfields within the Hazaribagh district. Prospecting operations during the years 1919-23 have for the most part been concentrated in the southern field and have proved very large quantities of coal. A characteristic feature of this field is the remarkable thickness of the seams. Some of these, 60 feet in thickness, are of frequent occurrence, while the "Lower Serka Thick Seam" has been proved at one place to contain 139 feet of coal. The coals vary in quality

[1] From information kindly supplied by Messrs. Bird & Co.

from inferior to other varieties containing less than 8 per cent. of ash, though as a rule the thicker sections of the better class coals are stated to have an ash content of from 12 to 15 per cent. In general, the coal is free burning with an infusible ash, a quality which may render those types possessing a higher ash percentage suitable for consumption under boilers and for similar purposes. Up to the end of 1923, over 17,000 *bighas* of land in the southern field had been let on mining leases to the Company. The South Karanpura Coal Company Limited hold a lease over 1,150 *bighas* in the Sirka tract of the south-eastern corner of the field. The two thick Sirka seams crop out within this property. These seams average about 50 feet and 130 feet in thickness, respectively, the upper and thinner seam being of uniformly first class coal, while of the lower, the greater part is of first class or of good second class quality. The property is being developed as a quarry and the removal of the overburden was commenced at the end of 1922. The coal will be excavated by a steam Navvy and loaded direct into wagons by means of an overhead cableway and bunkers. It is anticipated that the railway from Bermo will be completed as far as the collieries in 1924. Good progress is also being made with the construction of a line, about 70 miles in length, to join the main Bengal-Nagpur Railway system at Chandil near Sini Junction, which will give a direct route to Calcutta, avoiding the congested lines passing through the Jharia and Raniganj coalfields.

Giridih Field.

A report on the Giridih field, which lies in the Hazaribagh district of Bihar and Orissa, was published by McClelland in 1850. He counted 70 seams with an aggregate thickness of 92 feet. The area of the field is only about 11 square miles, of which 7 square miles are occupied by Barakar rocks, but it is of great importance on account of its position and the fact that it produces one of the best steam coals in India The principal seams that have been worked are the Karharbari lower. with an average thickness of 15 feet, 4 inches, the Karharbari upper with an average thickness of 6 feet and the Bhaddoah, with an average thickness of 6 feet. The remaining seams have an aggregate thickness of 66 feet but much of the coal in them is of inferior quality. The field is greatly dislocated by faults and traversed by numerous dykes of basalt and mica-peridotite which have destroyed many thousands of tons of coal.

Analyses of the seams are as follows:—

—	Carbon, per cent.	Volatile matter, per cent.	Ash, per cent.
Lower seam	66	24·42	9·15
Upper seam	60·46	28·11	11·96
Bhaddoah seam . . .	61·24	22·96	15 84

In 1894 it was estimated that 82½ million tons of coal were still obtainable, but since then some 22 million tons have been mined. The output for the past five years was as follows:—

	Tons.
1919	950,045
1920	831,293
1921	818,580
1922	659,101
1923	713,598

The largest mines are at Serampore and Karharbari and are the property of the East Indian Railway Company, but there are smaller ones worked by private owners. By-product coking has been in operation at the East Indian Railway Company's collieries for a number of years.

Other producing fields of Bihar and Orissa.

Jainti is a small field with an area of about 5 square miles in the south of the Santal Parganas, in the vicinity of the Adjai River. Coal was obtained here as early as 1909, but proper mining dates from 1914. The output for the period under review is given below.

	Tons.
1919	152,941
1920	118,651
1921	105,652
1922	96,612
1923	82,166

The Sambalpur coalfield was known many years previous to 1891, when a seam of coal of fair quality was passed through during sinking operations for a bridge over the Ib river on the Bengal Nagpur Railway. After boring operations had been conducted a

colliery was established in 1909, and the outputs within recent years have been as follows :—

	Tons.
1919	45,574
1920	36,987
1921	77,277
1922	68,618
1923	50,796

The average composition of two samples from the Ib bridge seam was as follows :—

Fixed Carbon	53·6
Volatile Matter	22·6
Water	8·5
Ash	15·3
	100·0

Daltonganj.

The Daltonganj coalfield is situated in the Palamau district and its coal-bearing rocks have an area of about 30 square miles. The distribution of the coal appears to be irregular. Coal was first discovered in this field about the year 1829 and collieries were opened in it during the forties by the Bengal Coal Company who are said to have extracted considerable quantities of coal and sent them down to the towns on the Ganges during the rainy season. These operations ceased in 1862 until 1901, when through railway connection was established with the main line of the East Indian Railway by the construction of the Daltonganj-Son Bridge branch line. In 1872, the field was fully surveyed by T. W. H. Hughes.[1] Its total area proved to be about 200 square miles, of which, however, only 30 square miles are occupied by the Barakars. Various estimates of the available resources have been made from time to time and differ very much amongst themselves. A series of borings put down by the Public Works Department in 1891 showed that, although two distinct seams occur over nearly the whole of the area, the coal is, for the most part, of such poor quality that only a small proportion of the total is of economic value. It was estimated, however, that about 9 million tons of fair quality coal were obtainable from an area of one square mile near Rajhara.[2] Analyses of two samples from the Rajhara seam then gave the following result.

	Per cent.
Fixed Carbon	49·37
Volatile Matter	27·63
Water	8·40
Ash	14·60

[1] T. W. H. Hughes: " The Daltonganj coalfield," *Mem. Geol. Surv. Ind.*, Vol. VIII, pp. 325-346 (1872)."

[2] T. H. D. LaTouche : " Boring Exploration in the Daltongunj coalfield, Palamow " *Rec. Geol. Surv. Ind.*, Vol. XXIV, pp. 141-153 (1891).

Recent analyses of two seams 12 feet and 10 feet thick respectively, which are worked, are as follows :—

—	No. 1.	No. 2.
Fixed Carbon	43·0	63·8
Volatile Matter	30·9	21·5
Moisture	6·6	1·2
Ash	19·5	12·8

The average annual output for the last period was 81,041 tons. During the period under review the field has produced as follows :—

	Tons.
1919	63,250
1920	39,113
1921	36,590
1922	31,933
1923	11,815

Coalfields of the Central Provinces.

The main areas covered by Gondwana rocks in the Central Provinces are in the Satpura Range, in the Godavari basin in the Nagpur, Wardha, Chanda and Yeotmal districts, in the Bilaspur *zamindaris*, and in some of the Feudatory States. Although some 30 coalfields exist, few have been worked, partly through lack of communications and partly owing to the inferior quality of much of the coal, which is generally second or third class when compared with the best coals of Bihar and Orissa. The most productive field is in the Pench Valley of Chhindwara, though there are other important mines at Mohpani in Narsingpur and in the Wardha Valley of Chanda.

According to the Central Provinces Administration Report of 1921-22 " the development of both the Pench and Chanda coalfields is hampered by lack of communications. Much of the former is traversed by the Itarsi-Amla-Parasia line and is served by the Khirsadoh-Chhindwara-Nagpur line, but many sidings a few miles in length and more siding accommodation at the Junardeo station are required ; the Great Indian Peninsula Railway has undertaken to enlarge the latter. Lack of waggons has also interfered with the despatch of coal. In the Chanda field the line linking the Pisgaon coalfield in Yeotmal with the Wardha-Chanda line at Majri is under

construction, but the greater part of the field remains too far from the railway for development."[1]

The Ballarpur colliery was opened up to take the place of Warora colliery, abandoned in 1906. In anticipation of the latter event, prospecting operations were undertaken by Government at Ballarpur, 38 miles to the south-east in the Chanda district, on the left bank of the Wardha river. Coal was proved by borings over an area of $1\frac{1}{2}$ square miles and a shaft was commenced. The large quantities of water met with in sinking proved to be a formidable obstacle, as all fuel used for the pumping engines had to be carried by road from Warora. Ballarpur was joined to the Great Indian Peninsula system by an extension of the Wardha-Warora branch, which was opened for traffic on the 1st February 1908. Meanwhile two 14-foot circular shafts had been sunk to the coal at depths of 257 feet (No. 1) and 236 feet (No. 2), and in 1906 a small quantity of coal was raised for use on the railway construction works. One of the shafts is lined with brick and ferro-concrete, and the other with fire-bricks moulded to the circle of the shaft. The colliery was ultimately sold to a private firm and was handed over on April 1st, 1913.

Ballarpur.

Ballarpur was the first colliery in India to adopt hydraulic stowage, which was introduced by the Manager, Mr. R. S. Davies, in March 1913. According to Mr. Davies, the seam at Ballarpur is 52 feet 6 inches thick. Two portions of it are workable. The upper portion is 24 feet 6 inches from the bottom of the seam and is 8 feet thick; the lower forms the bottom part of the seam and is also 8 feet; this leaves 16 feet 6 inches between the workable portions, which, with the remaining upper 20 feet, are composed of shale and coal. To extract all or the greater part of the coal of these two workable sections, it was decided to work the upper portion first and to adopt hydraulic sand-packing to keep intact the roof, to prevent strata and surface water from flooding the mine, and as a preventive against fire.[2]

During the period under review, the output of Ballarpur rose from 135,375 tons in 1918 to 171,425 tons, in 1921. The coal, like most of that obtained from the Gondwana rocks of the Central Provinces, contains a large percentage of moisture. The following

[1]Report of the Administration of the Central Provinces and Berar for the year 1921-22, p. XXIII.

[2] *Trans. Min. Geol. Inst. Ind.*, X, 53 (1916).

two assays were made in the Geological Survey laboratory on samples obtained when the seam was being first opened up.

	Per cent.	Per cent.
Fixed Carbon	45·47	45·21
Volatile Matter	31·56	30·61
Moisture	11·10	13·51
Ash	11·87	10·67
	100·00	100·00

The average number of persons employed daily at Ballarpur during the period 1919-23, was 867; there were 9 deaths during the period, the death-rate being 2·07 per 1,000.

The annual figures of persons employed were as follows:—

	Persons
1919	892
1920	862
1921	1,068
1922	1,069
1923	445

The large decrease in the labour force employed in 1923 was due to the closing of the colliery owing to an outbreak of fire on the 26th June 1922. It was necessary to clo e the shafts and they remained sealed until the middle of August 1923. The mine was only worked for 4½ months during 1923; for this reason the colliery is now being electrified.

In addition to the Ballarpur colliery, the same company has others working at Ghugus, Sasti and Rajara. The Sasti coalfield is the name given to that portion of the field which extends across the Wardha river into Hyderabad territory. According to Hughes, who surveyed the Wardha Valley coalfields in 1886-87, the productive area of the Ghugus field covers about 3 square miles with an estimated available supply of about 90 million tons.[1] A colliery was originally opened here in the early seventies but was closed within a few years owing to the more advantageous position of Warora. It is only within recent years that mining has been commenced here

[1] *Mem. Geol. Surv. Ind.*, Vol. XIII, p. 98 (1887).

once more. Analysis of 32 samples from a boring near Ghugus gave the following result:—

Fixed Carbon	45·61
Volatile Matter	33·49
Ash	20·90

A more recent assay of Ghugus coal yielded the following:—

Volatile Matter	41·8
Fixed Carbon	35·3
Moisture	7·7
Ash	15·2

A sample of coal from Sasti assayed as follows:—

Volatile Matter	45·6
Fixed Carbon	29·5
Moisture	8·3
Ash	16·6

Pench Valley.

The coalfields of the Pench Valley (Chhindwara) in the Central Provinces are worked both by joint-stock companies and private owners. The total output for the whole valley in 1922 was 453,484 tons. The Chhindwara fields are situated on the southern banks of the Satpura Range in the valleys of the Tawa, Kanhan and Pench rivers and cover an area of about 100 square miles. The Pench Valley coalfield has an area of 7·4 square miles and is one of the five semi-detached areas referred to above. The whole area was surveyed by E. J. Jones in 1887 and his report[1] which has long been out of print was recently republished at the expense of the Government of the Central Provinces. In the Barkui, a Pench Valley field, three workable seams have been proved with thicknesses of 9½, 5 and 5 feet respectively. The quantity of coal available is stated to be not less than 100 million tons. We are indebted to Messrs. Shaw, Wallace & Company for the following notes on the collieries under their managing agency. In all there are six collieries opened up, *viz.*:—

1. Barkui, served by the Bengal Nagpur Railway.

2. Jatachappa, Dongar Chickli, Bajipani and Eklahra, served by the Great Indian Peninsula Railway.

3. Chandametta, served by both these railway systems.

In addition to these collieries work has been carried on at Dongaria, Jamai, Batta, Badi and Ambara, which are situated some ten miles east of the older collieries. Operations on this new area have, however, been very restricted owing to their distance from the railway and lack of siding accommodation.

[1] E. J. Jones : The Southern coalfields of the Satpura Gondwana Basin : *Mem. Geol. Surv. Ind.*, XXIV (1885).

During 1923 difficulty was experienced in disposing of the output from this field owing to the importation of English, South African and Japanese coal into Bombay, which is the natural outlet for Pench coal.

Mohpani.

The oldest colliery in the Central Provinces is Mohpani. The Mohpani coalfield is situated in the Narsinghpur district on the south side of the Narbada alluvial valley, andat the foot of the northern spurs of the Satpuras. The divisions of the Gondwana system exposed in this field are the Mahadevas, the Barakars, and the Talchirs, the known coal-seams lying, as usual, in the Barakars. About forty years ago the Sitariva Coal Company carried out a certain amount of work on the field, but the actual development of the Mohpani coalfield is due to the efforts of the Nerbudda Coal and Iron Company, Limited, which commenced operations in 1862, and from then until 1904, spent more than £150,000 on the undertaking. The mines are divided into the "old field" and the "new field." The "old field" was abandoned in 1902 after practically the whole of the coal workable by the existing shafts had been won, the total amount so extracted being 450,845 tons, the deepest shaft being the Helen pit, 405 feet deep, and the number of coal-seams four.

The "new field", forming part of a second concession adjoining the "old field", was first opened up in 1892, and up to the end of 1903 the Company had raised 181,080 tons of coal and splint from the two upper coal-seams. As in the old workings on the Sitariva river, faulting and heavy water discharge were, in 1903, giving considerable trouble; consequently in order satisfactorily to work out the already proved coal, additional capital was necessary for hauling and pumping plant. This capital the shareholders of the Nerbudda Coal and Iron Company were unwilling to supply. On the other hand, the Great Indian Peninsula Railway Company, to whose system the mines are connected by a ten-mile branch line to Gadarwada, and who had been taking the output of the Mohpani collieries at a uniform rate of Rs. 6 a ton, was dissatisfied with the small output; consequently, after a report by Mr. R. R. Simpson, the properties were sold to the Great Indian Peninsula Railway Company for £40,000 with effect from the 1st July 1904. Since then the output has increased rapidly; from 22,998 in 1905 it rose to an annual average of over 50,000 tons in the period 1909-13, and to as much as 78,792 tons in 1918.

In the course of his examination of the field, Mr. Simpson made estimates as to the quantity of coal still left to be extracted, and came to the conclusion that the amount of coal and splint proved by the workings was 1,610,379 tons of coal in Numbers 1 and 2 seams, and 411,076 tons of splint in Number 1 seam. In addition to these, he estimated that 725,081 tons could safely be assumed as obtainable from Numbers 3 and 4 seams, and that an additional quantity of 4,833,902 tons of coal could reasonably be assumed to be obtainable from seams Numbers 1 to 4 and the upper and lower seams of the 1895 area, together with 426,018 tons of splint from Number 1 seam. The grand total thus estimated to be available is 7,169,362 tons of coal and 837,094 tons of splint. In making these estimates, Mr. Simpson assumed an extraction of two-thirds of the coal worked. The thicknesses of the four seams are :—

No. 1 seam	11 feet of coal with an intermediate band of 6 feet of splint, the specific gravities of coal and splint averaging 1·48 and 1·70 respectively.
" 2 "	25 feet.
" 3 "	5 feet.
" 4 "	6½ feet.

In the 1895 area, the thicknesses are taken as—

	Feet.
Upper seam	18,
Lower seams	9,

the extraction assumed for this area being 50 per cent. In addition, it is considered possible that a considerable quantity of coal may eventually be found in the old field, to the dip of the Helen pit. at a considerable but by no means unworkable depth; to prove this boring will be necessary.

While examining the field Mr. Simpson took ten average samples of coal from seams Numbers 1 and 2 and one sample of the splint in seam Number 1. In 1908, Mr. F. L. G. Simpson, who was then manager of the Mohpani collieries, took a series of twelve samples of coal representing all the four seams (one of them being of the splint) for the purposes of the Nagpur Exhibition. These samples were subjected to approximate analyses in the Geological Survey laboratory. In Table 23 below are given the extremes and means of these twenty-one analyses of coal and of two analyses [1] of splint; and

[1] Some of these, together with some ultimate analyses and coke assays of Mohpani coal by Mr. C. S. Fawcitt of Bangalore, and a complete analysis of ash from Number 7 bottom seam, also by Mr. Fawcitt, are given in the report on the Mining Section of the Central Provinces Exhibition in *Trans. Min. Geol. Inst. Ind.*, IV, pp. 134 and 135 (1909).

also an average of thirty-nine assays of Bengal coal, taken from Mr. R. R. Simpson's report. Speaking generally, the coal is somewhat inferior to the average of Bengal coals. Mr. R. R. Simpson quotes figures for trials on the Great Indian Peninsula Railway showing the following comparative equivalencies :—

Sanctoria (Bengal)	1·00
Singareni	1·18
Mohpani	1·32
Warora	1·57
Umaria	1·62

Sanctoria coal is distinctly superior to the average Bengal coal, and it can be taken that 1¼ tons of Mohpani coal are equal to one ton of average Bengal coal.

TABLE 23.—*Assays of coal from the Mohpani field.*

—		Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur.	Calorific value in heat units (C).	Evaporative value in lbs. of water.
MR. R. R. SIMPSON'S SAMPLES (1904).	Highest	57·54	32·04	4·60	35·98	..	..	..
	Lowest	39·50	17·86	1·28	15·50	..	..	..
	Average of 10 assays.	*48·96*	*24·51*	*2·52*	*24·01*	..	..	..
	Splint	37·90	21·02	2·84	38·24	..	..	..
MR. F. L. G. SIMPSON'S SAMPLES (1908).	Highest	53·03	34·20	5·97	22·94	0·79	7,187	13·38
	Lowest	43·96	25·65	4·06	9·79	0·23	5,578	10·38
	Average of 11 assays.	*48·34*	*29·81*	*5·28*	*16·57*	*0·37*	*6,427*	*11·97*
	Splint	31·94	23·06	3·68	41·32	0·85	4,400	8·19
BENGAL COALFIELDS.	*Average of 39 assays.*	*53·70*	*31·30*	..	*15·00*	..	..	..

It is now customary to divide the "new field" into two areas, known respectively as areas A and B. During the period under review development work has been continued on area A, the annual average outturn being 86,128 tons. The whole of this, with the exception of dust sold to local brick-makers, was taken by the loco-

motive department of the Great Indian Peninsula Railway. Electrical power plant and Marens screening machinery have been installed and the colliery is now one of the best equipped mines of its kind in India.

The coal in this area is very susceptible to spontaneous combustion and underground fires have been known to occur in the centre of solid pillars, consequently all the areas from which pillars have been removed (goaf) are closely packed with sandstone and earth sent down from the surface for the purpose. With a view to minimising the high raising costs consequent on such a system, experiments have been carried out recently with hydraulic stowing to replace the hand-packing. The experiments have been very successful and have proved that the output from the mines can be increased 100 per cent. by this method, provided sufficient packing material exists within a distance of 6,000 feet from the mines. When the arrangements for universal hydraulic stowing have been completed—and they are well in hand at the time of writing—it is estimated that an output of 150,000 tons per annum, with a corresponding reduction in costs of production, will be obtained.

The area "B" comprises some 150·57 acres situated about one mile to the west of area "A." An anticlinal ridge, striking S. 35° W. bisects this area and carries the outcrops of the four coal seams which it contains. It is probable that the area will be found to contain about 3 million tons of workable coal. With the exception of the sinking of two trial shafts near the outcrop which struck Number L seam at a depth of 110 feet, and of the driving of a few galleries, very little work has been done in the area. It is heavily watered and the inclination of the seams is as high as 1 in 6.

The following table gives the usual statistics for the Mohpani field during the years 1919-23.

Year.	Annual output of coal.	Daily average number of persons employed.	No. of fatal accidents.	Average death rate per 1,000 persons employed.	Average death rate per 1,000 tons of coal raised.
1919 . . .	85,299	1,572	3	1·90	·03
1920 . . .	83,335	1,697	2	1·17	·03
1921 . . .	89,623	2,006	1	·49	·01
1922 . . .	84,996	2,036	1	·49	·01
1923 . . .	87,387	1,699	1	·58	·01

We are indebted to Mr. R. A. Husband, Manager, Mohpani Colliery, for much of the information given above.

Umaria.

The Bilaspur-Katni branch of the Bengal-Nagpur Railway passes through the coalfield of Umaria in Rewa State, Central India. The quantity of workable coal in this field is estimated to be about 24,000,000 tons. During the period of the last review, the average annual output was about 178,000 tons but during the period now under consideration this has fallen to an average of 140,000 tons, the approximate figures for each individual year being as follows:—

	Tons.
1919	182,000
1920	158,000
1921	155,000
1922	118,000
1923	96,000

There are three seams in the field varying from about 3 to 13 feet in thickness. The one which is worked at present has a thickness of from 10 to 13 feet and dips at about 4° to the north-east. The mines were opened in 1882 under the direction of T. W. H. Hughes of the Geological Survey of India and were controlled by Government until the 1st January 1900, when they were handed over to the Rewa State, to which they are a source of considerable profit; the net total earnings during the period 1919-23 amounted to Rs. 10,40,000, while those for the period 1914-19 were about Rs. 11,00,000.

The average number of persons employed daily at the collieries during the period under review was 1,388, the figures for each year being as follows:—

1919	1,293
1920	1,617
1921	1,467
1922	1,270
1923	1,295

The number of deaths was 9, giving the average death-rate for the period as 1·29 per 1,000 employed.

Sohagpur.

A commencement has been made with the development of the Sohagpur coalfield during the period under review, resulting in outputs of 37,060, 42,693 and 80,125 tons in 1921, 1922 and 1923 respectively. The field was geologically mapped and described by T. W. H. Hughes in 1885.[1] Under the name of Sohagpur, however, Hughes treated an area of 1,600 square miles, including the Jhagrakhand coalfield which later writers have separated. The latter has an area of 22 square miles in the Korea State of the Central Provinces and a slightly larger expanse in Rewa State. L. L. Fermor has termed that portion of the Sohagpur field which lies within the northern part of Korea State, the Sanhat coalfield.[2] This practically necessitates the inclusion of two narrow strips of coal-bearing territory lying within the Jhilmili *tahsil* as part of the Jhilmili coalfield, although they were placed by Hughes in his Sohagpur field. As thus defined the Sohagpur coalfield lies wholly within Rewa State, between latitudes 23° 5′ and 23° 33′ and longitudes 81° 14′ and 82° 15′, with an area of slightly less than 1,200 square miles. A recent writer, K. P. Sinor, delineates the area in much the same way but includes in Sohagpur that portion of the Jhagrakhand field situated in the south-eastern corner of Rewa.[3]

Nine-tenths of the area are covered by Barakar rocks, bounded to the west and north by Mahadevas and to the east and south by Talchirs. No estimates have been made of the quality of coal available and as far as present information goes, coal-seams appear neither abundant nor thick. On the other hand, however, owing to the low dip of the strata and the great area that they cover, such seams as are of workable size and quality can be easily excavated and should yield very large quantities of coal. Details of the outcrop of seams and their analyses are given in the papers by Hughes and Sinor. One of the best is found near the junction of the Katna and Son Rivers where it has a thickness of 5 feet and has been traced for 10 miles. The following analysis is given by Hughes :—

Fixed Carbon	55·0
Volatile Matter	29·5
Moisture	5·8
Ash	9·7

[1] *Mem. Geol. Surv. Ind.*, XXI, pt. 3 (1885).
[2] *Mem. Geol. Surv. Ind.*, XLI, pt. 2 (1914).
[3] *Bull. No. 2. Geol. Dept. Rewa*, 1923.

According to Sinor, later investigations show that the seam varies from 15¼ feet on the Bageha to about 5 feet on the Son; he quotes the following three analyses:—

—	A.	B.	C.	Average.
Fixed Carbon . . .	58·96	53·34	42·88	51·73
Volatile Matter . . .	28·06	27·51	24·30	26·62
Moisture	1·12	1·25	1·30	1·22
Ash	11·86	17·90	31·52	20·43
	Bright.	Fairly bright.	Bright and dull.	

The bright coal coked well and the calorific values of two samples were 6,050 and 5,555, respectively.

The Sohagpur field is already served in its south-western division by the Bilaspur-Katni line of the Bengal-Nagpur Railway, and quarrying operations have commenced in earnest near the Bageha to the south of the railway line in the Burhar-Amlei area. The maximum thickness of coal here is about 24 feet, but the normal thickness is about 10 feet.

Promising, though rather thin, seams of coal have also been found recently in the eastern part of the field and are certainly good enough to warrant exploratory work by boring.

Undeveloped coalfields of Central India and the Central Provinces.

Although it has not been customary in the past to discuss in this review the undeveloped coalfields of India, the definite announcement of a policy of railway extension to put them into communication with industrial centres and ports brings them into such prominence that they can no longer be passed over in silence. Various railway reconnaissance surveys have taken place with this object in view but none is more important than the Central India Coalfields Railway Reconnaissance survey which links up the Bilaspur-Katni branch of the Bengal-Nagpur Railway with the proposed Horilong-Hesla line of the East Indian Railway with its through communications to other existing termini at Daltonganj on the coalfield of the same name and Bermo on the Bokaro field of the Damuda Valley. Although it would be

premature to discuss the merits of the various routes which have been proposed to tap this isolated region, a few notes on the coalfields that may be affected by one or other of the future lines may be given. In the early part of 1923 the subject was investigated by Mr. A. L. Coulson of the Geological Survey of India who has submitted a detailed report.

The Sanhat coalfield is the name given by Dr. Fermor to that part of the Sohagpur field lying within Korea State. It has an area of about 550 square miles, and was first examined by T. W. H. Hughes and Hira Lal. In 1913 it was re-examined by Dr. Fermor.[1] It contains two principal seams the lower of which is valueless in the western half of its course, but shows thicknesses of 4 to 9 feet over a length of 16 miles in the eastern part of the field. The upper seam is valueless in the east but ranges from 3½ to nearly 10 feet in the west. The result of a considerable number of assays shows that neither seam is of good quality, the ash content ranging from 15·38 to 32·24 per cent. in the case of the lower seam and from 22·98 to 36·68 in the case of the upper.

The area of the Jhagrakhand coalfield as defined in the previous section of this note (*see* Sohagpur) is about 60·7 square miles. It was examined by T. W. H. Hughes and Hira Lal and is described in the former's memoir already quoted. Prospecting licenses have been taken out over portions of the area and there appears to be little doubt that mining will commence as soon as railway facilities are provided. Summarising the available evidence Mr. Coulson concluded that there are three coal-bearing horizons in this field. Of these the most important is the lowest, but the second also possesses economic importance. The lateral extent of the highest is believed to be small and its seams thin. In the lowest horizon there are two seams averaging about 4 feet and 6 feet of coal with a sandstone parting of 13 to 28 feet. The average of six analyses is given below.

Fixed Carbon	55·92
Volatile Matter	27·35
Moisture	6·00
Ash	10·73
Calorific Power	6,772

The lateral extent of the horizon is probably about 4 or 5 square miles with about 30·8 million tons available per square mile. In

[1] *Mem. Geol. Surv. Ind.*, XLI, pt. 2 (1914).

the second horizon, so far as is known at present the coal is of second class quality and the reserves considerably less.

Kurasia.

The Kurasia field occupies an area of about 48 square miles in the south central portion of Korea State. Here, according to Dr. Fermor, there are 6 coal horizons, in one of which (No. 4) there are from 2 to 5 seams ranging in thickness from 1 foot to 8 feet 6 inches. This horizon is supposed to cover about 4 square miles, in which case an average thickness of coal of, say, 5 feet, would correspond to 5½ million tons per square mile. This however, must still be proved by boring. The ash content of the coal ranges from 9·32 per cent. to 13·82 per cent. Better coal still is found in the Churmiri section of the Kurasia field, in which seven seams aggregating 38 feet in thickness are known. A table is given below showing the comparative composition of the coals of the Sanhat and Kurasia fields.

—	SANHAT FIELD.		KURASIA FIELD (HORIZON 4),	
	Seam No. 1 lower.	Seam No. 2 upper.	Kurasia area.	Churmiri area, Kauria stream.
Number of assays . . .	3	5	6	10
Fixed Carbon . . .	44·80	44·00	48·86	51·20
Volatile Matter . . .	28·22	24·00	30·92	29·68
Moisture	5·79	4·19	8·66	7·94
Ash	21·19	27·81	11·56	11·18
	100·00	100·00	100·00	100·00

This series of seams appears to thin out gradually in all directions; but it is considered that there are from 1 to 1½, possibly even 2, square miles over which the coal is at least 10 feet thick. It is estimated therefore, that at least 7 million tons of good coal are available—possibly a considerably larger quantity. The dip of the seams is universally low. Three large firms have been granted concessions in this coalfield and as soon as railway communication is established development should be rapid.

The smallest of the Korea State coalfields, Koreagarh, has an area of about 6 square miles and lies 2 miles to the south-east of the Kurasia field. Very little is known of its potentialities though three seams of medium quality have been reported to occur. Its future is quite problematical.

Koreagarh.

Under the name of the Jhilmili coalfield, Ball designated a portion of the Sohagpur field lying practically within the Jhilmili *tahsil*. Dr. L. L. Fermor, by applying the name Sanhat field to the northern and eastern part of Sohagpur field lying within the boundaries of Korea State, includes the south-western corner of Ball's Jhilmili field. Ball's own observations were never published but were used by Hughes in his description of the Jhilmili field. The coal-bearing rocks, *i.e.*, the Barakars, occur in three strips designated the southern, central and northern areas. Mr. Coulson, as a result of his own observations, concludes that there are four coal horizons in the southern area. In the central area four outcrops of coal were examined, but more could easily have been found had time permitted. The northern area was not examined. Though a small field and at present in its virgin state it is thought to possess potentialities, as the coal in the southern and central areas appears to be of good quality, and there are indications of two seams of coking coal in the southern area. No estimates of quantity are possible until borings have been put down.

Jhilmili.

The name Bisrampur coalfield [1] was applied by V. Ball to an area of about 400 square miles of coal-bearing Barakar rocks in Central Sarguja. The Barakars throughout the whole area are practically horizontal with gently rolling dips, so that the seams can at times be traced for long distances. Faults are uncommon and when they do occur are of small magnitude. Many outcrops of thin seams have been described, some of which are of good quality but correlation is impossible and the framing of estimates hopeless in the absence of boring records.

Bisrampur.

Although coal was discovered in the Singrauli field in 1840 our knowledge of it is still very scanty. Its area is said to be about 200 square miles and it lies mainly in Rewa State with an extension into the south-western corner

Singrauli.

[1] V. Ball: *Rec. Geol. Surv. Ind.*, Vol. VI, pp. 25-41 (1873).

of the Mirzapur district of the United Provinces, between latitudes 24° 12′ and 23° 47′ and longitudes 81° 48′ and 82° 52′. In 1896 Griesbach reported the discovery by R. D. Oldham of two seams 6 feet and 5½ feet thick and remarked "There is here a large coal-field with an abundant supply of coal but too remote from existing lines of communications to hold out any prospect of successful working in the immediate future."[1] Sinor has given a list of 11 outcrops of seams in the Rewa State,[2] and Coulson has tabulated the following analyses :—

—	11 ANALYSES.	
	Average.	Limits.
Volatile Matter	25·47	30·27— 8·72
Fixed Carbon	40·60	52·72—29·96
Ash	25·64	44·44—11·74
Moisture	8·29	15·52— 2·08
Calorific Power	4,707	5,636—3,503

Seams varying from 3 to over 18 feet thick are known to occur and 60 or 70 years ago coal was mined at Kota and carried by camels to Mirzapur, 80 miles away, for use on the Ganges river steamers.

Here, as in so many other cases, it is impossible to form any idea of quantities which may be available in the absence of detailed geological investigations and borings.

Talchir Coalfield.

Coal was discovered in the Talchir State of Orissa in 1827. In 1855 the field was surveyed by W. T. and H. F. Blanford and W. Theobald, with the disappointing results summarised by T. Oldham in the first volume

[1] *Rec. Geol. Surv. Ind.*, Vol. XXX, Pt. 4 (1897).

[2] *Loc. cit.*, p. 55.

of the memoirs of the Geological Survey of India. It was not until 1919 that a systematic drilling campaign revealed the existence of two seams, 12 and 8 feet thick, carrying considerable quantities of coal, while the existence of several other seams was proved. In 1921 the field was examined by Dr. L. L. Fermor who has given the following analyses of the coals.[1] :—

—	Seam 1.		Seam 3.	
	Average of 12 samples.		Average of 8 samples.	
	As taken.	Moisture free.	As taken.	Moisture free.
Fixed Carbon . . .	44·11	49·75	46·18	52·31
Volatile Matter . . .	35·65	40·20	30·54	34·59
Moisture	11·33	..	11·71	..
Ash	8·91	10·05	11·57	13·10
	100·00	100·00	100·00	100·00
Calorific value of dried samples	..	7,056	..	6,737

The greater proximity of the Talchir field to the Madras Presidency than that of the other fields of Bengal, Bihar and Orissa, makes it important as a potential source of supply for Southern India. A company has been formed to develop the field and operations are in progress, so that, when the 65 miles of railway now under construction connecting the field with the Bengal-Nagpur Railway at a point north of Cuttack are completed, raisings can start at once.

Loi-an Coalfield, Southern Shan States, Burma.

A re-examination of the Loi-an coalfield near Kalaw in the Southern Shan States of Burma, in 1922 has proved that the coal is of Gondwana and not of Tertiary age as was formerly supposed. The coal-seams have been greatly crushed by earth movements and the material is friable; this not only adds to the difficulties of mining but

[1] *Rec. Geol. Surv. Ind.*, Vol. LIV, p. 19 (1922).

may necessitate some form of briquetting before the coal can be placed on the market. The seams are irregular and dip mostly at high angles, while faulting and contortion are prevalent. Some of the seams, however, appear to be of good quality, and further prospecting is being carried on.

By-product coking.

It is now over fifteen years since the first by-product coking plant was erected in the Indian coalfields; this consisted of 18 Simon Carvès ovens which were installed at the East Indian Railway Company's collieries at Giridih. Subsequently, a second battery of 12 ovens was added while an additional 50 ovens are under construction now.

The example set by the East Indian Railway Company was followed during the last period by installations at the Tata Iron and Steel Company's works at Jamshedpur (50 Koppen ovens), at the Bengal Iron Company's works at Kulti (64 Simon Carvès ovens), and at Lodna colliery in the Jharia field (30 Simon Carvès ovens). A battery of Koppen ovens was also completed at the Loyabad colliery in the same field.

Owing to the continued progress of the Indian iron and steel industry, the consumption of by-product coke has continued to increase during the present period, and several new plants have been erected and additions to old plants carried out, as follows :—

The Bararee Coking Co. Ltd. . . .	35 Simon Carvès ovens.
The Indian Iron and Steel Co. Ltd. . .	150 Simon Carvès ovens.
The Bengal Iron Co. Ltd.	32 Simon Carvès ovens (extension).
The Tata Iron and Steel Co. Ltd. . . .	150 Wilputte Carvès ovens (extension).
The Eastern Coal Co. Ltd. (Bowra) . .	25 Semet Solvay ovens (extension).

The total capacity of the by-product coking plants of India is now well over 1,000,000 tons per annum, against about 200,000 tons in 1918.[1]

[1] Information kindly brought up-to-date by Mr. Marshall of Giridih.

Singareni.

The great belt of Gondwana rocks, near the north-western end of which Warora is situated, stretches down the Godavari Valley as far as Rajamundry, and at one or two places the equivalents of the coal-bearing Damuda series in Bengal are found cropping up from below the upper Gondwanas. One of these occurrences near Yellandu in the Nizam's Dominions forms the well-known Singareni coalfield. In 1872 the outcrop of a seam of coal, of which not more than 2 feet were exposed, was discovered by W. King of the Geological Survey of India. The area covered by Barakar rocks was found to be about 9 square miles and borings revealed the existence of four seams measuring from above downwards, 30 to 40 feet, 6½ feet, 4½ feet, and 3 feet 9 inches to 7 feet in thickness respectively. Only the lowest of these, known as the King seam is worked. Mining commenced in 1886. During the five years ending 1913 the average annual output was 497,646 tons rising to 619,571 tons in the next quinquennium.

During the present period outputs have been as follows :—

	Tons.
1919	662,196
1920	666,335
1921	646,047
1922	604,358
1923	629,225

An analysis of the coal of the King Seam is as follows :—

	Per cent.
Fixed Carbon	56·50
Volatile Matter	25·25
Moisture	7·60
Ash	10·65

The collieries were opened up by the Hyderabad (Deccan) Company, Limited, but in December 1920 they were transferred to a new company, Singareni Collieries, Limited.

Tertiary Coalfields.

As has already been noted, all the coal being worked outside the Gondwana coalfields is of Tertiary age. Coal of this age is found in Baluchistan, Sind, Rajputana, the Punjab, along the foot-hills of the Himalaya, further east in Assam, in Burma, and in the Andaman and Nicobar Islands. The most frequent occurrence is in association with nummulitic limestones (Eocene), although the richest deposits, *viz.*, those in North-eastern Assam, are younger, probably Miocene. The output from each of these Tertiary fields for the years 1919 to 1923 is shown in Table 24. From this table it will be seen that the output of Tertiary coal during the period under review averages a little over 442,000 tons a year.

On the whole, the younger coals, which are being worked in extra-Peninsular areas, differ from the Gondwana coals in containing a larger portion of moisture and volatile hydrocarbons, and though as variable in composition as they are in thickness of seam, coals are obtained—as for instance in Assam—with a remarkably low percentage of ash and having a high calorific value. The high proportion of moisture in some of these younger coals, is however, often a serious cause of deficiency in calorific value. The difference between the Tertiary coals and Gondwana coal from Bengal is well seen in Table 25, which gives the extremes and averages of analyses of five samples of coal from Assam, two from Baluchistan, one from Burma, and five from the Punjab, given in a paper on the "Composition and Quality of Indian Coals" by Professor W. R. Dunstan[1]; it also shews the average of thirty-nine samples of Bengal coal by Mr. R. R. Simpson.

North-Eastern Assam.

The coalfields which are situated on the north-western slopes of the Eastern Naga Hills in the Lakhimpur and Sibsagar districts of Assam, are of great economic importance to that province. The existence of coal in this

[1] *Rec. Geol. Surv. Ind.*, XXXIV, pp. 239-241 (1906).

TABLE 24.—*Production of Tertiary Coal during the years 1919 to 1923.*

—	1919 Tons.	1919 Per cent. of Indian Total.	1920 Tons.	1920 Per cent. of Indian Total.	1921 Tons.	1921 Per cent. of Indian Total.	1922 Tons.	1922 Per cent. of Indian Total.	1923 Tons.	1923 Per cent. of Indian Total.
Assam—										
Khasi and Jaintia Hills	600		570		443		453		200	
Makum	259,652	1·29	285,974	1·81	269,198	1·62	291,747	1·83	270,343	1·65
Naga Hills	29,941		38,991		42,824		55,903		55,606	
Sibsagar	1,541		..		..		..		..	
Baluchistan—										
Khost	23,703	0·15	22,535	0·19	31,253	0·28	33,866	0·31	26,504	0·22
Sor Range, Kalat, Mach.	10,625		11,406		23,374		26,269		16,058	
Burma—										
Kamapying (Mergui)	..	..	..	..	..	..	..	..	163	0·00
Kale (Upper Chindwin)	..	..	..	..	..	..	..	..	213	0·00
Namma (Northern Shan States).	1,500	0·01	..	..	..	..	..	..	..	..
North-West Frontier Province—										
Hazara	20	..	..	..	..	..	...	..	..	..
Punjab—										
Jhelum	35,845		47,803		50,639		47,832		43,253	
Mianwali	5,822	0·21	6,835	0·32	11,852	0·35	14,301	0·35	11,965	0·32
Shahpur	5,226		3,440		4,751		5,047		8,283	
Rajputana—										
Bikanir	14,760	0·06	18,216	0·10	24,521	0·13	15,055	0·08	7,119	0·04
Total (Tertiary Beds)	**389,235**	**1·72**	**435,770**	**2·42**	**458,855**	**2·38**	**490,473**	**2·57**	**439,707**	**2·23**

region has been known since 1825 and the question of opening out the fields was examined by committees which assembled in Calcutta in 1840 and 1845. The localities were examined by Medlicott in 1865 and were carefully investigated by Mallet in 1874-76. The coal measures of the Makum field stretch for 40 miles to the north-east and have been traced for 110 miles to the south-west through the fields of Jaipur, Nazira (Dikhu and Safrai), Jhanzi ("Jangi") and Desoi ("Disai"). Important seams occur between the Tirap and Namdang streams, where for about 5 miles, they vary from 15 to 75 feet in thickness. Several desultory attempts were made from time to time to open up the Makum field but little success was attained until 1886 when the area was leased to the Assam Railways and Trading Company and a railway was constructed from the Brahmaputra at Dibrugarh to the coal measures on the Dehing. At the present time there are mines at Burra-Gulai, Ledo, Tirap, Namdang and Tikak and the output has risen to nearly 300,000 tons per annum. Near Margherita, where the collieries are situated, the average thickness of the thickest seam now being worked is about 50 feet of coal, with intercalations of fire-clay amounting to 10 feet; in the Namdang section it increases to as much as 80 feet, and is persistent, with little variation, for a distance of 6 miles. The average dip is 40°, but as the outcrops in many places are several hundred feet above the plain, facilities exist for working the coal by adit levels. The average coal production of the Makum mines during the last five years has been 275,383 tons a year, as compared with 291,005 tons during the preceding period. The coal has the reputation of being a good fuel, and forms an excellent, though sulphurous coke. Mr. R. R. Simpson has sampled the coal-seams being worked in the Upper Ledo and Tikak mines in this field.[1]

The average composition given by three samples from the Upper Ledo colliery representing an aggregate thickness of 49 feet, and by five samples from the Tikak colliery representing an aggregate thickness of 47 feet, is shown below:—

	Upper Ledo	Tikak
Fixed carbon	55·59	58·99
Volatile hydrocarbons	40·15	37·25
Moisture	1·80	2·09
Ash	2·46	1·67
TOTAL	100·00	100·00

[1] *Rec. Geol. Surv. Ind.*, XXXIV, pp. 239-241 (1906).

TABLE 25.—*Average Assays of Tertiary and Gondwana (Bengal) Coals.*

—		Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur.	Calorific value in heat units (C).	Evaporative value in lbs. of water.
Tertiary: higher grade : Assam and Baluchistan—	Highest .	53·28	46·48	5·83	9·56	4·87	7,702	14·34
	Lowest .	41·50	40·42	1·45	1·27	0·74	6,028	11·22
	Average of 7 assays.	*48·99*	*43·58*	*3·19*	*4·24*	*3·14*	*6,926*	*12·90*
Tertiary : lower grade : Burma and Punjab—	Highest .	39·44	47·08	10·85	39·91	4·41	6,730	12·53
	Lowest .	27·79	26·85	3·47	8·50	0·33	4,270	7·95
	Average of 6 assays.	*34·57*	*38·89*	*6·56*	*19·98*	*1·91*	*5,610*	*10·45*
Bengal Coal .	*Average of 39 assays.*	*53·70*	*31·30*	..	*15·00*	..	..	..

The mean of two assays of Makum coal performed in 1922 in the laboratory of the Geological Survey of India was as follows :—

Fixed Carbon . . .	53·2 per cent.
Volatile Matter . . .	44·0 ,, ,,
Moisture	1·2 ,, ,,
Ash	1·6 ,, ,,

Makum coal is largely used by railways in Assam, by the river steamers navigating the Brahmaputra river and by a large number of tea gardens in the province. Considerable quantities are also exported to Bengal.

Mr. Simpson[1] has examined the Jaipur and Naziracoal fields lying to the south-west of the Makum field. He confirms the estimate previously made by Mr. Mallet with regard to the large quantity of good fuel in these two fields; in addition to the estimates of coal that can be proved, there is the probability of larger quantities hidden by the alluvial deposits, but in many places the seams are highly inclined, and, being below the level of permanent saturation, will be difficult to work except with special precautions to deal with the water.

A portion of the Dikhu or Nazira field, situated at a short distance within the hills whence that river issues, is held on lease by the Singha Tea Company, but, except for the needs of the lessees, has not yet been worked to any extent. The Nazira Coal Company is working the seams on the east of the Dikhu River in the Borjon and Kongon mines, within the Mokochang sub-division of the Naga Hills. Operations were started here in 1913 but, owing to the War and the delay in obtaining plant, no coal was despatched until late in 1917. The outputs since that date have been as follows :—

1918	24,299 tons.
1919	29,941 „
1920	38,991 „
1921	42,824 „
1922	55,903 „
1923	55,606 „

The mine is worked from adits driven into the hill side and the coal is transported by means of an aerial ropeway for a distance of about 4 miles to the siding on the Assam-Bengal Railway.

The thickness of the seam is about 7 feet and owing to the difficulty of maintaining a roof the adits have, in the past, been driven in coal to a distance economical for hand-tramming, and from that point the area so opened out is worked back and another adit driven at a higher level up the hill. A series of these workings have been driven varying between levels of 600 feet and 1,500 feet above the sea. At present a more economical method of working is being adopted which entails cutting the seam at the lowest level obtainable by a pair of stone drifts some 2,000 feet in length. From this point an endless-rope haulage-way will be driven in the rock, running below and parallel with the strike of the seam, for a distance of 1½

[1] *Rec. Geol. Surv. Ind.* XXXIV, pp. 199-238 (1906)

miles; from this road districts will be opened up in the coal at suitable intervals.[1]

The quality of the coal from these fields is shown by a series of analyses[2] which are summarised below. The sulphur in five of the Jaipur coals averaged 1·87 per cent., and in five of the Nazira coals 3·35 per cent.

Coal of excellent quality also occurs in the Namchik valley, a tributary on the left bank of the Dihing River, three days' journey above Margherita. The locality, which, although only 18 miles in a straight line from Ledo, is difficult of access, was examined by Dr. E. H. Pascoe in 1911. Five groups of seams were noticed, with a total thickness of about 60 feet of coal.[3]

TABLE 26.—*Assays of Coal from the Jaipur and Nazira coalfields.*

—		Fixed carbon.	Volatile matter.	Moisture.	Ash.
Jaipur Field	Highest	53·71	45·10	10·31	18·18
	Lowest	41·38	35·49	3·95	1·10
	Average of 25 assays	*48·78*	*39·80*	*6·42*	*4·82*
Nazira Field	Highest	54·64	42·90	7·23	14·45
	Lowest	45·49	34·36	3·89	2·22
	Average of 12 assays	*50·04*	*38·11*	*5·49*	*6·36*

Burma.

Coal occurs in many districts of Burma, including Bhamo, Upper Chindwin, Henzada, Katha, Kyaukpyu, Mergui, Pakokku, the Shan States, Shwebo and Thayetmyo. With the exception of the Southern Shan States deposits already referred to, it is all of Tertiary age and has proved to be

[1] Based on information kindly supplied by Messrs. Shaw, Wallace and Company.
[2] *Rec. Geol. Surv. Ind.*, XXXIV, pp. 227-230 (1906).
[3] *Rec. Geol. Surv. Ind.*, XLI, p. 214 (1912).

either of such poor quality, or present in such thin seams or in such isolated localities, as to render its extraction unprofitable up to date. It is impossible to describe all the occurrences in detail or even to summarize the somewhat extensive literature which has grown up around them, in the short space available here, and all that can be done is to indicate very briefly the better known localities.

The only district from which any regular outturn has been registered is that of Shwebo, in which district coal was being mined at Lethobin and Ketzubin near Kabwet in 1870. The seam was about 6 feet thick but much of it was of poor quality. W. King inspected the field in 1894 and came to the conclusion that the area over which coal of good quality occurs is very restricted, and thought that the quantity available would not be more than 150,000 tons.[1] The output of the mines was at that time from 10,000 to 15,000 tons annually. It reached a maximum of nearly 23,000 tons in 1896, but after considerable fluctuations the mines were closed down in 1904.

Northern Shan States.

The coal measures of the Northern Shan States occupy a series of detached basins grouped around the base of Loi-Ling, the highest mountain in the States. These basins which lie on the Plateau Limestone are filled with sand-rock, shales and lignitic coal-seams, probably of Pliocene or Pleistocene age, and are similar in age and character to the lacustrine, lignite-bearing deposits of the adjoining Chinese province of Yunnan. The following fields have been examined :

Lashio. The existence of coal in the Lashio area was first recorded by Noetling in 1891. In 1904-05 the field was surveyed by LaTouche and Simpson who found its area to be about 50 square miles with the coal exposed in seven places in the bed of the Nam Yan river, along the southern edge. The seams varied in thickness from 1 foot to 33 feet and consisted of a brownish-black lignite with a woody texture, liable to rapid disintegration on exposure to the air. The material has been tried as a locomotive fuel but the results were unsatisfactory. Its average composition, the mean of 6 analyses, is as follows[2] :—

	Per cent.
Fixed Carbon	31·08
Volatile Matter	35·63
Moisture	20·65
Ash	12·64

[1] *Rec. Geol. Surv. Ind.*, XXVII, pp. 33-34 (1894).

[2] *Rec. Geol. Surv. Ind.*, XXXIII, pp. 117-124 (1906).

Man-sang. The Man-sang area covers 13½ square miles and contains numerous outcrops of a hard, shaly lignite, none exceeding 4½ feet in thickness.

Man-se-le. The Man-se-le field covers an area of 13½ square miles and includes apparently only one seam of workable thickness.

Nam-ma. The Nam-ma field has an area of about 50 square miles. Two seams are of economic importance; one of these varies from 7 to 17 feet in thickness.

The Nam-ma coalfield, which lies about 30 miles south of Lashio, the terminus of the Shan States branch of the Burma Railway, was thoroughly explored by the Burma Mines, Limited, in 1918-19, and the main seam opened up by a double track slope to a depth of 750 feet. Two seams were proved, an upper one from 10 to 15 feet thick, with an average of 12 feet, and a lower one from 19 to 40 feet thick, with an average of 21 feet. The strata between the two seams are loosely cemented sandstones and clays maintaining a thickness of 21 feet. The upper seam has a characteristic band from 3 to 6 inches thick, about its middle. Below the lower seam there is a 2 feet layer of quick-sand, heavily charged with water.

The coal is badly weathered at the surface, but further down is a lustrous black lignite with a dark brown streak and a specific gravity of 1·4 to 1·5. When fresh it breaks with a conchoidal fracture but on exposure it loses some moisture and breaks into cubical fragments. It burns with a bright flame and yields a light coke of no strength. An average analysis is as follows :—

	Per cent.
Fixed Carbon	45
Volatile Matter	37
Moisture	14
Ash	4
Calorific value (B. T. U.)	9.000

E. Moldenke considers 50,000,000 tons of coal in the lower and 30,000,000 tons in the upper seam, very conservative estimates of the contents of the proved part of the basin.[1]

[1] Geology of the Namma Coal Field, Burma, *Trans. Amer. Inst. Min. Eng.*, LXVI, pp. 299-302 (1922).

The three fields of Nam-ma, Nan-sang and Man-se-le were reported on by Simpson in 1905 and the following analyses are taken from his report[1] :—

——	Man-sang ; average of 6 samples.	Man-se-le ; average of 1 sample.	Nam-ma ; average of 5 samples.
	per cent.	per cent.	per cent.
Fixed Carbon	36·32	34·22	38·81
Volatile Matter	35·13	38·83	36·90
Moisture	14·23	14·73	16·58
Ash	14·32	12·22	7·71

Coal also occurs in the neighbourhood of Wetwin, but neither its age nor quantity has been determined. Three samples collected by the writer gave the following average result on analysis[2] : —

	Per cent.
Fixed Carbon	33·59
Volatile Matter	38·38
Moisture	16·39
Ash	11·61

Kamapyin Coalfield, Mergui.

Another interesting coal-bearing basin of Tertiary age occurs at the other extremity of Burma in the valley of the Tenasserim River, Mergui district. It was first brought to notice by Hoefer in 1838, and from that time onwards has been visited and described by various writers, while proposals have often been made both by Government and private venturers to work it on a large scale. Until quite recently, however, no systematic boring of the area appears to have been undertaken.

In 1893 P. K. Bose carried out a detailed survey of the field, to which the name Tendan-Kamapyin was given. The coal-measures cover an area of about 30 square miles and in the Kamapyin area a seam with an average thickness of 15 feet was found, extending a distance of three quarters of a mile, with an available quantity of

[1] *Rec. Geol. Surv. Ind.*, XXXIII, pp. 125-156 (1906).
[2] *Rec. Geol. Surv. Ind.*, XLV, p. 112 (1915).

600,000 tons within a depth of 200 feet. In the Tendan area the thickness of the seam was taken to be 4 feet and the quantity available about half the above amount. The following analysis of the coal is given[1] :—

	Per cent.
Fixed Carbon	44·24
Volatile Matter	35 08
Moisture	16 40
Ash	4.28

In 1918, Dr. A. M. Heron reported on the field for the Government of Burma.

During 1923, part of the field has been energetically prospected by boring, pitting and shaft-sinking under the auspices of the Burma Finance and Mining Company who report that nine boreholes altogether have been put down, the total footage sunk being over 2,000 feet. Two small shafts and eight pits have also been sunk and over 230 feet of driving on the No. 1 seam carried out from the main shaft at an incline depth of 80 feet from the surface.

The net result of this work has been to prove the existence of a very large tonnage of coal which, owing to the length, width and regularity of the seams, can be easily and cheaply mined. Over 120 tons of the coal have been brought down the Tenasserim river and supplied to consumers in Burma for testing purposes. The results of these tests have been to show that the coal, although not of the best quality, is a good usable fuel for which there should be a ready market, provided it can be supplied at a price which compares favourably with the cost of coal imported into Burma. The company is paying special attention to economical methods and the provision of cheap and efficient transport from the mine to the market.

Henzada District.

The coal occurrences of the Henzada district were described by Romanis in 1882[2] and Stuart in 1912.[3] The seams which are known to exist at Hlemauk ("Hleemouk"), Posugyi ("Posogyi") and Kyibin seem to be too small and too poor in quality to warrant further attention; at Kywezin ("Kywaising") there is an outcrop about 10 feet in

[1] *Rec. Geol. Surv. Ind.*, Vol. XXVI, pp. 148-164 (1893).
[2] *Rec. Geol. Surv. Ind.*, XV, pp. 178-181 (1882).
[3] *Rec. Geol. Surv. Ind.*, XLI, p. 254 (1912).

thickness with a high easterly dip and greatly faulted and contorted. The analysis given below shows a high proportion of fixed carbon :—

	Per cent.
Fixed Carbon	74·44
Volatile Matter	17·59
Moisture	1·68
Ash	6·29

Attempts to mine this material in the past have not been attended with any measure of success and its future is exceedingly problematical.

Pakokku District.

Dr. G. de P. Cotter has reported on the coal-seams of the Letpanhla and Tazu areas of the Pakokku district and has concluded that, although numerous and fairly thick in places, they are marred by frequent partings which with their weak roofs would make them expensive to work. Furthermore, the quality of the coal is very poor owing to the high percentage of moisture and the presence of excessive sulphur, and finally, the localities are far removed from any railway and are 46 miles distant from the Irrawaddy river.

Upper Chindwin.

Coals of Tertiary age have long been known to occur in the hills to the west of the Chindwin above Kalewa. A section on the Kale river above its confluence with the Chindwin was examined by E. J. Jones in 1887. He found ten seams within an area of one square mile, all of which with a single exception were considered useless.[1] In 1893 Dr. F. Noetling's report on his survey of the field was published by the Government of Burma. The field was shown to have a wide extension, the coal measures occupying the valleys of the Nantahin, Peluswa, Maku and Telong streams, to the north of the Kale, for a distance of 55 to 60 miles. According to Noetling considerable quantities of coal of very fair quality are available within easy reach of the river ; his report should be consulted for fuller details.[2]

Baluchistan, Khost.

The largest coal-mines in Baluchistan are those worked by the North-Western Railway at Khost in the Sibi district. In addition to these there are a few smaller mines worked both by joint-stock companies and by private owners in the same area, and a few more small mines in the Sor Range of the Quetta-Pishin district.

[1] *Rec. Geol. Surv. Ind.*, XX, p. 172 (1887).
[2] Note on the Upper Chindwin Coal Fields, Rangoon (1893).

The Khost colliery was opened in 1877 and the two seams worked there have average thicknesses of 26 and 27 inches respectively. In addition to the stratigraphical difficulties usually associated with mining coal-seams of Tertiary age, which are often irregular in thickness and lie in disturbed, uncertain ground, there are additional dangers due to the liability of most of these pyritous coals to spontaneous combustion, and to the ever-present chances of explosions caused by the large quantities of dust set free in working such friable coals. These natural hindrances are intensified by the scarcity of trained mining labour. During the previous period the Khost colliery produced an average of 33,490 tons per annum. For the years under consideration its output was as follows :—

	Tons.
1919	23,703
1920	22,535
1921	31,253
1922	33,866
1923	26,504
AVERAGE	27,572

A full account of the conditions under which mining has been carried on at Khost and of the methods adopted in briquetting the dust coal has been given by A. Mort. The Khost coal is of fair quality and cokes well, but it contains a considerable amount of pyrites. An average analysis is given below :—

	Average of 6 samples.
Fixed Carbon	46·52
Volatile Matter	41·51
Moisture	2·28
Ash	8·84

As was the case for the greater part of the previous quinquennium, mining operations have been carried on at a loss at this colliery during the period under review.

TABLE 27.—*Summary of the Financial results of working the Khost Colliery during the years 1918-19 to 1921-22.*

Years.	Gross earnings.	Working expenses.	Net earnings.
	Rs.	Rs.	Rs.
1918-19	2,17,686	2,76,745	—59,059
1919-20	1,91,502	2,67,676	—76,174
1920-21	2,26,719	3,25,594	—98,875
1921-22	2,64,597	4,32,940	—1,68,343

Dandot, Punjab.

The earliest connected accounts of the coal deposits of the Punjab Salt Range are those published between the years 1848 and 1853 by A. Fleming. Strangely enough, he considered the Dandot seam to be of no importance, though it is the only one in the Salt Range which has proved amenable to large scale mining operations. The only available seam varies in thickness from 18 to 39 inches, forming a basin under the nummulitic (Eocene) limestone. It forms part of the single coal-bearing horizon which underlies the scarp of these limestones and extends along the crest of the range from east to west. The horizon itself is a band of sandstones and shales in which the coal is found at intervals in lenticular beds which are separated by wide intervals of barren ground.[1] Mining has been carried on at Dandot and at Pidh, 3 miles to the north-west, for many years, and between 1884 and 1912 the collieries were worked by the North-Western Railway Company after which they were purchased by Messrs. Thakur Dass and Ramji Dass. The working of the mines has always been attended with much difficulty, owing to the unstable character of the shales forming the floor and roof of the seam and the liability of the coal to spontaneous combustion. During the preceding quinquennium the output of the Jhelum district averaged 44,479 tons per annum. The figures for the present period are given below :—

	Tons.
1919	35,845
1920	47,803
1921	50,639
1922	47,832
1923	43,253
AVERAGE .	45,074

[1] A. B. Wynne: *Mem. Geol. Surv. Ind.*, Vol. XIV, pp. 105-293 (1878).

The annual output per miner employed at Dandot during the last five years has averaged only 35·7 tons, against 99·3 tons per man on the coalfields of Bengal, and Bihar. The loss of life through accidents was 1·42 per 1,000 compared with 2·05 per 1,000 for the years 1914-18.

Shahpur District: Punjab.

Coal-seams, similar to those of Dandot and Bhaganwala (where a small seam was worked between 1877 and 1900), in the Jhelum district, occur further to the west in the Shahpur district, the principal localities being Tejuwala near the crest of the southern scarp of the Salt Range, 12½ miles slightly to the west-of-north from Dhak on the Sind-Sagar branch of the North-Western Railway, and Jhakarkot, 3½ miles south-west of Tejuwala. The seam is about 3 feet thick but varies considerably within short distances. A small amount of work was prosecuted here in 1890, but abandoned after the extraction of a few hundred tons of coal. Operations were commenced again by Messrs. Bhagwan Dass and Ram Das in 1905, and during the succeeding years some 40,000 tons of coal were won. During the period under review the average annual outturn was 5,349 tons, compared with a little over 5,000 tons for the previous period. The mines are now owned by a private company known as the Northern India Coal Company.

Mianwali District: Punjab.

There are two distinct coal-bearing horizons in the neighbourhood of Isa Khel in the Mianwali district. One of these is of Jurassic age and need not be considered further here while the other at Mulla Khel is of Tertiary age; a seam in the latter has been traced for a distance of 6½ miles along the flanks of the Maidan Range, where it has an average thickness of 2 feet 3 inches. It was examined in detail by Mr. R. R. Simpson in 1904, and estimated to contain about 493,000 tons above full drainage level.

Analyses of the coal are given below :—

	Average of 21 samples.	Average of 3 samples assayed in 1922.[1]
Fixed Carbon	40·0	46·8
Volatile Matter	37·0	42·7
Moisture	9·0	4·3
Ash	10·0	6·2
Sulphur	4·0	4·3

[1] By W. Randall in the Geological Survey Laboratory, Calcutta

The output for the period was as follows :—

	Tons.
1919	5,822
1920	6,835
1921	11,852
1922	14,301
1923	11,965
AVERAGE	10,155

Palana, Rajputana.

The Palana coal-seam was discovered originally during the sinking of a well, at a depth of 212 feet from the surface, below a band of nummulitic limestone. At this point its thickness averaged 6 feet but on being opened up it was found to vary from 3 to 30 feet and to be persistent over a considerable area. A colliery was started in 1898 at a point where the seam possesses a thickness of 20 feet and a branch line, 10 miles long, was constructed to put it into communication with the Jodhpur-Bikaner Railway. The output reached a maximum of 45,078 tons in 1904, but after that there was a steady fall to 11,449 tons in 1909. There have been small fluctuations since then, and the average annual output during the previous quinquennium (1914-1918) was only 13,24 5tons. The figures for 1919-1923 are given below :—

	Tons.
1919	14,760
1920	18,216
1921	24,521
1922	15,055
1923	7,119
AVERAGE	15,934

The coal like so many of the Indian Tertiary lignites is dark brown in colour, with a woody texture, and becomes very friable on exposure to the air. This physical characteristic is naturally a disadvantage in a locomotive fuel. It has been proved by experiment, however, that considerable improvement can be brought about by a special process of briquetting which not only makes the coal more suitable for handling but actually reduces the high moisture

percentage and renders it less susceptible to atmospheric action.[1] Analyses of the coal, and of briquettes made from it, are given below.

——	Coal.	Briquettes (average of 2 samples).
Fixed Carbon	38·16	38·79
Volatile Matter	35·36	42·50
Moisture	22·90	12·08
Ash	3·58	6·63

Labour.

Coal-mining still continues to occupy the leading position it has held for long, as the chief source of employment for all forms of Indian mining labour. During the period under review the average number of persons employed daily was 200,351, being on the average 35,029 higher than the figure for the preceding quinquennium. In spite of this, throughout the whole of the years under review there has been a marked shortage of labour on all the principal fields, while the general efficiency has been disturbed by an unusually large number of strikes consequent on political agitation. The provincial distribution of labour is shown in Table 28, from which it will be seen that the share taken by the Bengal and Bihar coalfields has decreased slightly, over 84 per cent. of the Indian colliers being employed in those provinces in the period under review as against 86 per cent. in the preceding period.

Indian Mines Act, 1923.

The Indian Mines Act, 1923, received the assent of the Governor-General on the 23rd February 1923, and the Government of India are taking advantage of its enactment to revise the regulations relating to the safety of mines and of persons engaged in mining. The new regulations came into force on the 1st July 1924. A Committee appointed to enquire into the coal dust danger have made recommendations as to the regulations to be enforced in order to minimise the risk of coal dust explosions in future.[2]

[1] W. H. Phillips : "Manufacture of Patent Fuel and Utility of Low Grade Coals." *Trans. Min. Geol. Inst. Ind.*, Vol. VI, pp. 43-56, (1911).

[2] Report of the Chief Inspector of Mines in India for 1922, p. 18.

TABLE 28.—*Number of persons employed in the Indian Coal-Mining Industry during the years 1919 to 1923.*

Province.	1919.	1920.	1921.	1922.	1923.	*Average.*	Per cent. of average total.
Assam . . .	3,230	3,171	3,389	3,636	3,901	*3,465*	1·73
Baluchistan . .	1,006	986	1,330	1,492	1,195	*1,202*	0·60
Bengal . . .	48,642	43,782	45,813	44,893	44,251	*45,476*	22·70
Bihar and Orissa .	129,927	118,260	126,431	119,790	123,554	*123,592*	61·69
Burma . . .	70	242	270	65	157	*161*	0·08
Central India .	1,293	1,617	1,967	2,595	2,762	*2,047*	1·02
Central Provinces .	6,306	8,403	12,152	13,255	9,857	*9,995*	4·99
Hyderabad . .	11,974	12,446	12,502	13,402	13,558	*12,776*	6·38
N.-W. F. Province .	5	..	..	..	..	*1*	..
Punjab . . .	1,191	1,320	1,898	1,686	1,544	*1,528*	0·76
Rajputana . .	108	115	127	99	99	*110*	0·05
Total .	**203,752**	**190,342**	**205,879**	**200,913**	**200,878**	*200,353*	**100·00**

Efficiency of the Indian Collier.

The efficiency of the Indian coal miner compared with that of the collier in most other countries continues to be low.

We are indebted to Mr. D. Penman, Inspector of Mines in India, for the following revised note on the use of electricity and coal

cutting machinery in the mines of the Raniganj and Jharia fields :—

"There has been a great advance in the use of electricity at Indian mines in recent years, and the following table shows the number of mines at which electricity was being used during the year 1922 :

MINERALS WORKED.

Province.	Coal.		Clay.		Sundry Minerals.		Total Horse-power of Motors installed.
	Number of Mines.	Horse-power.	Number of Mines.	Horse-power.	Number of Mines.	Horse-power.	
Assam . . .	1	30	..	..	..	..	30
Bengal . . .	35	9,285	..	..	..	..	9,285
Bihar and Orissa .	52	19,172	..	..	1	1,677	20,849
Burma . . .	..	..	..	..	5	2,040	2,040
Central Provinces .	1	490	2	65	2	149	704
Total .	**89**	**28,977**	**2**	**65**	**8**	**3,866**	**32,908**

From this table it will be seen that while the bulk of the electric plant is installed at coal mines, nearly 4,000 horse-power is being utilised in the mining of other minerals. The provinces of Bengal and Bihar and Orissa lead the way in the use of electric energy.

At most of the important collieries, electricity is being used for pumping, ventilating, haulage, coal-cutting, etc. The saving in the consumption of coal for power purposes is very marked. In underground operations nearly 70 per cent. of the power is employed for pumping and it is in this work that the greatest service has been obtained from electricity. In keeping the mines free from water during the Rains, de-watering inundated workings and in the sinking of shafts through water-logged strata, electricity possesses conspicuous advantages over steam-power. Next to pumping, electricity is most largely used for haulage purposes. At two mines in the Jharia coalfield electric locomotives, operating on the trolley system, have been installed. Electric winders are in use at quite a number of mines and are giving satisfaction. One plant in the Raniganj field raises coal from shafts 1,500 feet in depth.

Both in the Jharia and Raniganj fields there are central generating stations which supply electric energy to groups of collieries. The current is generated and transmitted at a high voltage and is transformed down at the individual mines to meet local requirements. Alternating current is universally used for transmission, although in a few cases it is converted to direct current for haulage and coal-cutting.

Coal-cutting machines continue to increase in number. During the year 1922 forty electrically driven cutters were at work in Raniganj and Jharia mines. Of

that number twenty-nine were of the chain and ten of the revolving bar type. One percussive machine was in use. There were also three machines operated by compressed air at work in a Jharia mine. Several machines were also in use in the coal mines of the Central Provinces. During the year 1923 there has been a considerable increase in the number of machines at work, and, in some collieries, practically the whole of the output is now obtained by machine mining. There is little doubt that the future will see important developments in this form of work in India and not only is it likely that the use of coal-cutting machines will be greatly extended, but there will probably be important advances in the handling and transportation of coal by mechanical means as well."

Death-rate from accidents.

Earlier reviewers have been fortunate enough to be called upon to emphasize the low average death-rate from accidents in the Indian coal-mining industry. It may be recalled here how the average annual death-rate per 1,000 persons employed during the years 1898 to 1903 was 0·88, varying between 0·68 (1898) and 1·32 (1899). During the next quinquennial period the rate was slightly higher, working out to 0·98 per 1,000 for all Indian coal mines, and varying between 0·72 in 1904 and 1·37 in 1908. There was a distinct rise in the average death-rate for the five years ending with 1913, the figure being 1·38 per 1,000 persons employed. This figure fell again to 1·14 for the period 1913-1918 with a maximum of 1·34 in 1916 and a minimum of 1·02 in 1917. During the present period the death-rate from accidents has unfortunately risen again to 1·36, the highest figure being 1·81 in 1923 and the lowest 0·99 in 1920.

TABLE 29.—*Production of Coal compared with deaths from coal-mining accidents in India.*

——	1919.	1920.	1921.	1922.	1923.	Average,
Deaths from coal-mining accidents.	287	189	286	243	363	*274*
Thousands of tons of coal raised for each life lost.	79	95	67	78	54	*75*
Lives lost per million tons of coal raised.	12·7	10·5	14·8	12·8	18·5	*13·9*
Death-rate per thousand persons employed.	1·41	0·99	1·39	1·21	1·81	*1·36*

It has been pointed out before how mining risks naturally increase with the deepening of mines and general extension of

workings underground, while additional dangers may be incurred by the anxiety to increase production during periods of urgent demand for coal, yet the reports of the Chief Inspector of Mines cannot be studied without the reader being impressed as to the large percentage of fatal accidents which investigation attributes to the fault of the deceased. In the year 1922 there was one accident due to the irruption of water into a mine and the Chief Inspector of Mines has pointed out that it is becoming increasingly difficult to prevent coal mines, especially in the Jharia field, from being flooded during the monsoons. The ground is everywhere broken up by subsidences and many of the entrances to the mines are situated in positions which render them liable to inundation. Whenever it is practicable to do so, mine owners erect protective works, either on their own initiative or at the instigation of the Mines Department, and where adequate protection cannot be given, all night work, and in many cases both night and day work, is stopped during the Rains, in the interests of safety.[1]

Coal mines, like all other mines, are worked under rules framed in accordance with the Indian Mines Act, but this Act applies to British India only and not to Indian States. The mines in British territory are under the constant vigilant inspection of the Mines Department. Certain of the larger Indian States maintain their own Inspectors of Mines and the Inspectors of the Government of India are also wanted at times to inspect the mines that are being worked in others.

TABLE 30.—*Comparison of Death-rate from accidents at Coal Mines in British India with those in Indian States during 1919 to 1923.*

YEAR.	AVERAGE NUMBER OF PERSONS EMPLOYED DAILY.		DEATHS FROM ACCIDENTS.		DEATH-RATE PER 1,000 PERSONS EMPLOYED.	
	British India.	*Indian States.*	British India.	*Indian States.*	British India.	*Indian States.*
1919 . .	190,377	*13,375*	260	*27*	1·37	*2·02*
1920 . .	176,164	*14,178*	172	*17*	0·98	*1·19*
1921 . .	191,283	*14,596*	257	*29*	1·34	*1·98*
1922 . .	184,817	*16,096*	209	*34*	1·13	*2·11*
1923 . .	184,459	*16,419*	332	*31*	1·80	*1·89*
Average .	*185,420*	*14,933*	*246*	*28*	*1·32*	*1·84*

[1] Report of the Chief Inspector of Mines in India for 1922, p. 7.

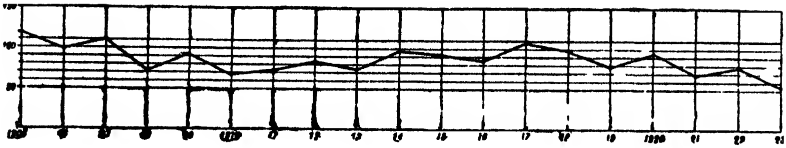

Fig. 9.—*Production of coal in thousands of tons per life lost by coal-mining accidents.*

During the period under review the average annual number of deaths from accidents at coal mines in Indian States was 28 against 246 at mines in British India, the death-rate being 1·84 per thousand in the former case against 1·32 per thousand in the latter. The details for each year are given in Table No. 30 from which it will be seen that, while there has been a steady increase of employment at mines in Indian States, the labour returns for mines in British India are somewhat capricious but on the whole indicate a decrease.

Table 31.—*Death-rate from Coal-mining accidents in the United Kingdom.*

——	1919.	1920.	1921.	1922. (*a*)	1923. (*a*)
Number of persons employed.	1,176,083	1,233,187	1,131,596	1,148,469	1,203,290
Number of deaths . .	1,118	1,103	756	1,101	1,293
Death-rate per 1,000 persons employed.	0·95	0·89	0·67	0·96	1·07
Deaths per 1,000,000 tons of coal raised.	4·87	4·81	4·62	4·41	4·68

(*a*) Figures for 1922 and 1923 relate to Great Britain only.

The returns for accidents at Indian coal mines can be compared with those of the United Kingdom in Table 31. The comparison is unfavourable to India, especially when we consider the number of lives lost in raising identical quantities of coal. This is obviously due to the low output per person employed in India. During the last five years we have lost by accidents on an average 13·9 lives per million tons of coal raised, while for the United Kingdom the loss is about one-third this rate. Still, it is perhaps fairer to judge the

risks incurred in an industry by the relation between the loss of life and the members who secure a comfortable and, under Indian conditions, a fairly happy livelihood. The gradual change in mining conditions in India, from shallow to deep, cannot but affect accident statistics, and it is only owing to the vigilance of those employed in mining as well as to those employed in administering the Mines Act, that the death-rate is not higher than it is.

Coalfields Committee.

In 1919, Mr. Treharne Rees, a mining engineer engaged by the Government of India for the purpose, visited the coalfields of Raniganj and Jharia, and in August of that year submitted a report on the best means of securing greater economy in the production and consumption of coal. The Coalfields Committee was constituted in January 1920 under a resolution from which the following quotation is taken :—

> "The Government of India have for some time had under consideration the question of devising means of reducing the large avoidable waste of coal known to occur at the Raniganj and Jharia coalfields, and due mainly to deficient methods of extraction, resulting in the total loss of a large amount of coal, to inefficiency in the generation and use of power and to extravagant methods of coke-making."

The terms of reference of the Committee were to consider the recommendations made in Mr. Treharne Rees' report, to report on the action which it would be possible and expedient to take in connection therewith, and, if legislature were involved, to consider the lines on which it should be framed.

After touring the coalfields and examining many witnesses the Committee issued its report later in the same year. This was signed by seven of the eight members of the Committee with a dissenting note by the then Mining Engineer to the Railway Board, Mr. R. W. Church. The principal recommendations of the majority report were as follows :—

(1) "That no improvement in the present wasteful methods can be expected without State interference, that such interference should take the form of a Controlling Authority

with legal powers designed to ensure conservation and economic extraction, and that such authority should consist of a new Government Department and a Board sitting in Calcutta."

(2) "That a steady and sufficient supply of wagons, with the requisite facilities for moving them is the most urgent need of the industry."

(3) "That sand-stowing should be made compulsory within certain limits and with provision for compensation, and that funds for the purpose should be raised by a cess and a duty of eight annas a ton on all coke and coal; that the cess should be imposed as soon as possible, be collected by the railway companies on despatches, and be administered by the controlling authority; that a Government Officer be deputed to ascertain the amount of sand available and that one or more railway officers be placed on special duty to enquire into the question of transport and distribution of sand."

(4) "That the Land Acquisition Act be amended to provide facilities for the acquisition of :—

(*a*) surface rights for colliery purposes,
(*b*) sand and other materials suitable for stowing, and
(*c*) land required for the conveyance of sand."

(5) "That labour recruitment, electrical development, briquetting and coal-washing should be left to private enterprise."

(6) "That the time is not ripe for compulsory weighment, statutory shifts, and restrictions on methods of coking."

Copper.

[E. H. PASCOE.]

Copper was formerly smelted in considerable quantities in Southern India, in Rajputana, and at various places along the outer Himalaya in which a persistent belt of killas-like rock is known to be copper-bearing in numerous places, as in Kulu, Garhwal, Nepal, Sikkim and Bhutan. In Chota Nagpur several attempts have been made to work lodes reputed to be rich in the metal, but in all such attempts the ore has been smelted for the metal alone;

no effort has been made hitherto to utilise the accompanying sulphur as a by-product. At Baraganda in the Giridih sub-division of Hazaribagh, a low-grade ore-body of about 14 feet in thickness was prospected by shafts to a depth of 330 feet, and an unsuccessful attempt was made many years ago to work the lode.

Singhbhum.

In the Singhbhum district of Bihar and Orissa a copper-bearing belt, marked out by old workings, persists for a distance of some 80 miles, stretching from Duarparam on the Bamini River in the Kera Estate, in an easterly direction through the Kharsawan and Saraikela States, into Dhalbhum, where the strike of the belt curves round to south-east, running through the Rajdoha and Matigara properties of the Cape Copper Company, Limited, to Bhairagora at the extreme south-eastern end.

The copper ores occur as rather indefinite lodes interbedded with the Dharwar phyllites and schists. Sometimes the ore is collected into fairly well-defined bands, but very frequently it occurs in the form of grains so sparsely disseminated through a considerable thickness of schists as to be unworkable. When concentrated into definite lodes, as at Matigara or Mosaboni, the ore may be of high grade, and well worth working, if it can be proved to exist in sufficient quantity to render it worth while to erect the plant necessary to handle large quantities of ore.

These copper-ores have been the subject of exploitation on European lines by various companies during the past fifty years, always until recently with disastrous results, in some cases due to the poor character of the deposit attacked, and in others to the unwise expenditure of a limited capital on expensive plant before the deposit had been proved. Such results have caused business and mining men to avoid the Singhbhum copper and consequently, in the absence of private enterprise, the Geological Survey of India, during the years 1906 to 1908, carried out a series of diamond-drilling operations on the belt. This directed attention to the problem, and the Cape Copper Company, after a further prospecting campaign, took over the Rajdoha Mining Company's rights at Matigara. The property, now known as Rakha Hills Mines, was actively developed and, had it not been for the difficulty of procuring plant during the war, smelting furnaces would have been in full operation before 1918.

At the end of August in 1918 the Company's ore reserves amounted to 407,000 short tons of an average assay value of 3·8 per cent. copper. An electric power house, a concentration plant

and a blast furnace with sintering and converting plants had been erected, and a refinery was completed during the quinquennium under consideration.

The following table shews the production of copper ore and metal from the Rakha mine during the period under review :—

	Copper ore raised from the mine.	Value of the ore.	Quantity of metal produced from the ore.	Value of the Metal.
	Tons.	Rs.	Tons.	Rs.
1919	32,756	5,24,096	980·25	11,76,300
1920	28,167	4,22,505	512·22	5,49,100
1921	32,560	4,88,400	833·11	9,58,076
1922	30,764	3,07,640	1,036·95	12,44,385
1923	6,550	65,500	187·23	2,30,293
TOTAL .	130,797	18,08,141	3,549·76	41,58,154

In March 1923 mining operations were stopped and the company's property was placed in the hands of receivers; the closing of the works, it is hoped, is only temporary.

As seen at the outcrops the Singhbhum lodes seem to be very poor where they have not been removed by the ancients. Typically they consist of a small thickness of vein quartz, associated with malachite, chrysocolla, and red oxides of iron containing a small quantity of copper, possibly as red oxide, with sometimes small encrustations of liebethenite. In depth as seen in the diamond drill cores and the levels of the Matigara mine, the ores consist practically entirely of chalcopyrite. The other minerals noticed above are evidently the outcrop alteration products of the yellow sulphide. Judging from small specimens found on the dump-heaps of the old workings there must be a zone of chalcocite not very many feet below the surface, probably formed by secondary enrichment at the expense of the portions of the deposits denuded away, and of those now appearing as gossans of oxide ores. The primary chalcopyrite ores have probably been deposited in their position as rather indefinite lodes following the bedding of the schists, after the arrival of the latter in their present position. The schists with which the copper lodes are associated are chiefly varieties of muscovite and chlorite-quartz-schists, with quartzite layers. Apatite and tourmaline are also common minerals in them.

TABLE 32.—*Production of Copper-ore during the years 1919 to 1923.*

	1919.		1920.		1921.		1922.		1923.	
	Quantity.	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Bihar and Orissa—										
Singhbhum .	32,756	*5,24,096*	28,167	*4,22,505*	32,560	*4,88,400*	30,764	*3,07,640*	6,550	*65,500*
Burma—										
Northern Shan States.	2	*63*	..	..	..	..	..	..	..	..
Mysore .	1	*(a)*	..	..	30	*(a)*	40	*(a)*	..	..
TOTAL .	**32,759**	*5,24,159*	**28,167**	*4,22,505*	**32,590**	*4,88,400*	**30,804**	*3,07,640*	**6,550**	*65,500*
Value in sterling		*£45,579 (£1=Rs. 11·5)*		*£42,250 (£1=Rs.10)*		*£32,560 (£1=Rs.15)*		*£20,509 (£1=Rs 15)*		*£4,367 (£1=Rs.15)*

(*a*) Not available.

The information obtained in the borings put down by the Geological Survey is shown in Table 33. These results show that much of the ore of Singhbhum is of low grade, and just below what is likely to be payable except when working on very large quantities of ore. A thickness of 16·80 feet, averaging 2·65 per cent. of copper, found at Laukisra, should offer some inducement for further testing by private enterprise.

The characteristic and persistent band of chalcopyrite with quartz blebs intersected by the Matigara bore-hole at 306 feet, where it yielded 12·81 per cent. of copper, but was only 3 inches thick, and which was seen in the Matigara mine in the 228-foot level with a thickness ranging from 6 inches to 2 feet, was followed on the dip in the Gladstone Shaft and found to extend below the depth proved by boring.

TABLE 33.—*Results of Diamond-drill Boring on the Singhbhum Copper Lodes.*

No. of bore-hole.	Locality.	Total depth of hole.	Depth of lode or cupriferous zone.	Actual thickness of lode assayed.	Percentage of copper.
1	Kodomdiha . .	..	392′—404′ .	8 feet . .	5·10
2	Do. . .	1,093′	1,069′ . .	1 foot . .	1·82
3	Galudih (Regadih)	430′	131′—294′ .	..	..
			203′ . .	13 inches . .	0·61
4	Landup (Nadup) .	465′	197′—198′ .	14 inches . .	3·33
5	Matigara . .	837′	693′—697′ .	3 feet 2 inches .	2·00
			697′—701′ 8″ .	3 feet 8 inches .	1·29
			733′ 5″—736′ 1″	2 feet 1 inch .	1·01
			736′ 1″—736′ 5″	3 inches . .	12·81
			736′ 5″—739′ .	2 feet . .	0·42
6	Laukisra . .	3?2′	150′—168′ .	16 feet 10 inches	2·65
			169′—171′ .	1 foot 10 inches .	2·13
			179′—184′ .	4 feet 8 inches .	1·37

Cordoba Copper Co., Mosaboni Mines.[1]

The Cordoba Copper Company, under the management of Messrs. John Taylor and Sons, commenced prospecting operations in the Mosaboni area, Singhbhum, in June 1920 and have met with most promising results. After piercing a zone of secondary enrichment in which the predominant ores were malachite and cuprite, an im-

[1] From information kindly supplied by the Superintendent, Mr. N. Kitto

poverished zone made its appearance in which there was practically no ore, although the lode channel was well defined. Beyond the impoverished zone chalcopyrite began to make its appearance in the shape of small lenses of ore. At a vertical depth of 169 feet from the surface, tunnels driven along the lode proved solid chalcopyrite, in some places 2 feet wide, over a considerable distance in length, giving values of from 10 to 25 per cent. of copper. Up to February 1924 twelve shafts had been sunk on this lode. Below the 169-foot horizon some promising ore ground carrying solid chalcopyrite is being opened up.

Another company, the North Anantapur Gold Mines, Limited, also managed by Messrs. John Taylor and Sons, commenced an investigation of the Sideshur-Kendadih copper area in Singhbhum in 1922. The area lies between the concessions of the Cape Copper Company and the Cordoba Copper Company. By the end of 1923 one shaft had reached 258 feet without intersecting the lode, but operations are still of a purely prospecting nature. The ore is a sulphide. This company is also exploiting copper in Kharsawan State, about eight miles N.W. of Amda Railway Station, Bengal Nagpur Railway.

Copper ore has been mined intermittently for many years by primitive native methods in the Darjeeling district.[1] The method of smelting has been described by Mr. F. R. Mallet (*Mem., Geol. Surv., Ind.*, Vol. XI, pp. 70-72). Indications of copper have been observed in over a dozen places of which eleven have been examined. The ore consists of copper pyrites, often associated with iron pyrites, and is usually of a low grade. It does not occur in true lodes but appears to be disseminated through the slates and schists of the Daling series. A seam said to be from 4 inches to a foot in width and to consist of solid ore, is exposed in the bed of the Chel River (26°, 58′: 88°, 46′). The mine two miles north-east of Kalimpong was abandoned on account of the hardness of the containing quartzite. At Komai (27°, 1′ : 88°, 51′) on the left bank of the Mo Chu copper ore is distributed in fairly large masses in bands from 2 to 4 feet in thickness occurring in slates [2]; a sample from a prospecting drift yielded on assay 3·5 per cent. of copper and 1 cwt. 8 grs. of gold per ton, while a picked sample gave 26 per cent. of copper.

[1] *Mem., Geol. Surv., Ind.*, XI, pp. 69-83; *Rec., Geol. Surv. Ind.*, XV, pp. 56-58; *Ibid.*, XXIII, pp. 257-258.
[2] *Ibid.*, XXXI, pp. 1-4.

At Mangphu on the left bank of the Tista there is an old copper mine whose annual output is said to have reached 5,760 lbs. of metal; the ore, which, is said to yield an average of about 4 per cent. of metal, occurs in lenticular layers up to a foot thick in a band of clay slate. Attempts to work the mine at Pashok between 1854 and 1870 were unsuccessful chiefly owing to the very low grade of this ore; the mine is now completely obliterated by a tea-garden. Near the head of the Chochi stream, 1,100 feet above and a mile north of Rani Hat, copper ore has been worked on a comparatively extensive scale; the ore stratum averages about 18 inches in thickness, and has been proved to a distance of over 90 feet along the dip. A copper mine was opened some 43 years ago on the western slope of Youngri Hill; the seam was, however, thin and the assay poor.

Sikkim.

Recent work has also proved the existence of lodes of possible value in Sikkim, where the copper is associated with bismuth, antimony, and tellurium, one of the minerals discovered being the rare mineral tetradymite Bi_2Te_3. Another mineral identified by the late Mr. Blyth in the Geological Survey Laboratory is linnæite, a sulphide of cobalt, Co_3S_4.

Prospecting licenses and mining leases were secured by Messrs. Burn & Company, in the copper-bearing areas in Sikkim, and extensive prospecting operations were conducted for some years; they were suspended, however, during the War, and have not been resumed. The following notes are from a report made in October 1908 by Mr. C. Wilkinson, showing the principal results obtained up to that date[1].

At Bhotang, 44 miles from Siliguri on the road to Gangtok, some old workings were examined and two parallel lodes of pyrrhotite were opened up and found to contain varying quantities of zinc blende, galena, and chalcopyrite. The lodes are disturbed but development work yielded results which were regarded as satisfactory.

At Kikchu, about 7 miles to the north of Gangtok and within a mile of the Gangtok-Lachen road, a distance of 75 miles from Siliguri, a more clearly defined copper-lode was discovered. It was found, by opening up the outcrops for a length of 200 feet along the bed of the Sehchu, that the lode had an average width of 3 feet, bearing 6·14 per cent. of copper. By cutting the vein at a greater

[1] Published with the kind consent, through the late Mr. A. Whyte, of Messrs. Burn & Co.

depth with an adit it was found that for 80 feet on an average width of 40 inches the lode contained an average content of 6·8 per cent. of copper.

In the Rhotak Colah, a tributary of the Great Ranjit river, 13 miles by pack road from Darjeeling, there are extensive old workings which have been almost obliterated by landslips. Five samples of the lode, taken at irregular intervals along a length of 500 feet, gave an average of 5·6 per cent. of copper.

At Sirbong, about 1 mile north-east of the junction of the Rhotak and Khani Colahs, a lode of pyrrhotite containing chalcopyrite was exposed, yielding, for an average thickness of 2 feet 6 inches, 6·45 per cent. of copper, the sampling being continued for about 100 feet along the outcrop.

The Pachikhani mine, which is reputed among the natives to be one of the richest of the mines in Sikkim, has been overwhelmed by a landslip, and has not yet been sufficiently opened for further examination (see Mr. Bose's remarks on this mine in *Records, Geological Survey of India*, Vol. XXIV, page 227).

Another deposit was found near Pachikhani on the road from Rungpo to Pakyong, about 7 miles from the former locality. It was found that the chalcopyrite, concentrated within a zone of mica-schist about 4 feet wide, yielded on an average 4 per cent. of copper.

Within 200 yards of the bridge crossing the Rungpo on the road from Rungpo to Rhenok, and about a mile to the north-east of the second of the two Pachikhani mines, there was found a quartzose vein following the foliation-planes of the Daling series and containing 3·97 per cent. of copper for an average thickness of 1 foot; it is considered that this ore could be readily concentrated by hand-picking.

In the neighbourhood of Pakyong in the Pachi Colah valley, two veins were found cropping out at right angles to the stream and at a distance of 200 yards from each other. The average analysis of the samples collected from one of these lodes gave the following results:—

Copper	3·30
Iron	11·23
Lead	10·10
Zinc	2·50
Sulphur	11·68
Silica	40·10

The other lode, consisting mainly of galena, varied in thickness from 6 inches to 2 feet, and contained an average of 21·12 per cent. of lead with 5·9 per cent. of zinc.

In 1911 the two most important of these deposits, namely, Bhotang and Dikchu, were examined by the Geological Survey of India.[1] As the result of this examination, development work was resumed at Bhotang with favourable results. Both deposits occur interbedded with the associated rocks, being of the nature of interbedded replacement deposits; but whereas the Bhotang deposit is in a comparatively unmetamorphosed form of the Daling series, the Dikchu deposit occurs in the belt of highly crystalline mica-schists with associated gneisses, forming a boundary zone between the Daling series and the Sikkim gneiss. In both cases, the copper-ore is chalcopyrite, the chief associated sulphide being pyrrhotite. But, especially at Bhotang, galena and blende are also of somewhat common occurrence. The origin and mode of occurrence of these ores appear to be similar to those of the Singhbhum copper lodes. In each area the bodies of copper-ore have been formed by the metasomatic replacement of the associated rocks; in each area also the copper-bearing formations are close to large masses of granitic rocks, from which, one may conjecture, the copper-bearing solutions were derived. In Singhbhum there are numerous basic (epidioritic) dykes associated with both the granites and the metamorphic rocks (schists, quartzites, etc.), and, as an alternative to the derivation of the copper-bearing solutions from the granites, it is possible to suppose them to be closely connected with the basic dykes.

Although the deposits of Sikkim are similar in mode of origin to those of Singhbhum, they differ from them remarkably in the diversity of their mineral contents, which frequently include chalcopyrite, pyrite, pyrrhotite, blende, and galena; in Singhbhum, on the other hand, the copper-lodes show, as a rule, only two sulphide minerals, chalcopyrite and pyrite, with traces of chalcocite at higher levels, probably representing a zone of secondary enrichment. In both Sikkim and Singhbhum, azurite, malachite, chrysocolla, and chalcanthite are found in the oxidised zones of the lodes, but in Sikkim, where the slopes are very steep and denudation under the influence of a moist climate and heavy rainfall very rapid,

[1] L. L. Fermor, *Rec., Geol. Surv., Ind.*, XLII, p. 75 (1912).

the oxidised zones are much less prominent than in Singhbhum. In Sikkim the sulphide minerals may crop out at the surface in the fresh condition, but this practically never happens in Singhbhum, where one might doubt the existence of copper deposits, were it not for the presence of numerous ancient outcrop workings stained with green and blue oxidised copper minerals.

One of the obstacles to a successful exploitation of the copper ores of Sikkim or Darjeeling is the inaccessibility of the areas and the lack of adequate communications. A successfully established water-power scheme in either area would add considerably to the prospects of. its copper deposits.

Bihar and Orissa.

Several attempts have been made within the last 70 years to reopen the old Baragunda copper workings in the Hazaribagh district of Bihar and Orissa. In 1888 the Bengal Baragunda Copper Company turned out 218 tons of refined copper, but the assays of average samples are not inviting, yielding between 1 and 3 per cent. of copper.

Burma.

Copper is found at Bawdwin in the Northern Shan States, and a high-grade copper-silver ore, carrying ·10·9 per cent. copper and 23 ounces of silver to the ton, is said to have been found recently in several bodies in that mine ; the reserves of this ore in 1919 were stated to be over 300,000 tons. Copper ore is also found in the Myitkyina and Katha districts, but no regular operations are carried on in either, and no ore-bodies of any value have yet been proved.

Madras.

Old copper workings on an extensive scale are to be seen in Nellore, in the neighbourhood of Garimanipenta (Ganipenta), but are confined mostly to the surface. The existence of payable ore at appreciable depths has never been investigated.

Rajputana and Nepal.

Copper has been mined at several localities in Jaipur, and deposits of unknown value are known to occur in Nepal.

Indian consumption of copper and brass.

That there is plenty of scope for the development of copper deposits in India to satisfy the Indian demand is seen by the magnitude of the imports of copper and brass. The average annual values of these for the period under review are shown in Table 34, together with the exports of Indian copper and brass wares (manufactured from imported metal), and the re-exports of foreign copper and brass,

From these it is seen that the value of the average annual consumption has been Rs. 2,09,07,779 in the case of copper and Rs. 2,70,10,600 in that of brass, as against Rs. 1,20,25,845 and Rs. 77,55,855, respectively, in the previous quinquennial period.

TABLE 34.—*Average Annual Exports and Imports of Copper and Brass for the five years 1919-20 to 1923-24.*

	COPPER.		BRASS.	
	Rs.	Rs.	Rs.	Rs.
IMPORTS	..	2,24,86,936	..	2,77,30,490
EXPORTS—				
Of Indian merchandise	3,44,994	..	5,28,147	..
Of foreign merchandise	6,90,588	..	1,75,533	..
Of Government stores	5,43,575	..	16,210	..
TOTAL EXPORTS	..	15,79,157	..	7,19,890
INDIAN CONSUMPTION	..	2,09,07,779	..	2,70,10,600

Diamonds.

[E. H. PASCOE.]

Distribution in India.

Notwithstanding the reputation (stretching back even as far as Ptolemy in the European, and further in the Hindu, classics) which India has had as a diamond-producing country, the output of to-day is very small and comparatively unimportant. The places which, according to accounts, have been most productive in the past form three great groups, each in association with the old unfossiliferous rocks of probably pre-Cambrian age, known as the Purana group, and distinguished locally as the Cuddapah and Karnul systems in South India, and as the Vindhyan system in the northern part of the Peninsula.

Southern group of occurrences.

The southern of the three groups of diamond-occurrences includes localities, with apparently authentic records, in the districts of Cuddapah, Anantapur, Bellary, Karnul, Kistna and Godavari. Loose stones have been picked up on the surface of the ground, and found in deposits of alluvium and in workings that have been

undertaken in the so-called Banganapalle stage of the Karnul series of strata.

Eastern group of occurrences.

In the second group of occurrences, in the Mahanadi valley, the stones have been found in the alluvium of the Sambalpur and Chanda districts, but, though strata similar to those of the Vindhyans and Karnuls are known in this area, no diamonds have been found in these older rocks.

Central Indian occurrences.

The third group of occurrences occupies a tract some sixty miles long by ten miles wide, with the Vindhyan conglomerates near Panna as the centre. The diamond-mining industry still persists in this area, both in the old conglomerate of Vindhyan age, and in the alluvium derived therefrom. The States in which diamonds are found are Panna, Charkhari, Bijawar, Ajaigarh, Kothi, Pathar, Kachhar, Baraunda, and Chobepur.

The following scale of strata will give an idea of the position of the diamantiferous beds with reference to the Upper Vindhyan rocks exposed in the Central India area—

BHANDER SERIES . . .	Upper Bhander sandstone. Sirbu shales. Lower Bhander sandstone. Bhander limestones. Ganurgarh shale.

Diamantiferous horizon.

REWA SERIES . . .	Upper Rewa sandstone. Jhiri shales. Lower Rewa sandstone. Panna shales.

Diamantiferous horizon.

KAIMUR SERIES . . .	Upper Kaimur sandstone. Kaimur conglomerate. Bijaigarh shale. Lower Kaimur sandstone.

The following is a summary of the principal results of a study by Mr. E. Vredenburg,[1] of the diamond-fields of Central India. In the neighbourhood of Panna the principal diamond-bearing stratum is a thin layer of conglomerate, locally known as *mudda*, lying between the Upper Kaimur sandstone and the Panna shales.

[1] *Rec., Geol. Surv., Ind.*, XXXIII, pp. 261-314 (1906.)

The conglomerate is seldom thicker than two feet and does not form a continuous bed. Further east, in the neighbourhood of Itwa, the diamond-bearing conglomerate does not rest directly on the Kaimur sandstone, but is separated from it by a 20-25-foot bed of shales and limestone. Another diamantiferous conglomerate occurs above the Rewa sandstones and under the Bhander series. This conglomerate differs from that below the Rewa series in the abundance of pebbles of vein quartz, instead of the different varieties of jasper found so commonly in the main diamantiferous conglomerate near Panna.

The diamonds in these conglomerates, like the associated large pebbles of lighter rocks, are derived from older rocks, and the original home of the gem is still unknown, though a precise recognition of the associated pebbles will gradually indicate the direction in which the mother-rock once occurred and possibly still exists. The most characteristic pebbles in the diamond-bearing conglomerates are the jasper-pebbles derived from the Bijawar formation and the vein quartz similar to that traversing the Bundelkhand granites, the latter being especially abundant in the conglomerate lying above the Rewa sandstone.

Besides the diamonds lying still embedded in the conglomerates others are found in the neighbouring detritus derived from the disintegration of the Vindhyan beds. The workings are developed accordingly—some with a view to the removal of the undisturbed conglomerate, and others with the intention of recovering the diamonds included in the more recently distributed detritus.

The undisturbed conglomerate is often covered by considerable thicknesses of younger Vindhyan rocks, and is reached by workings which are often, but not always, deep; these may be called 'direct workings.' In other places the overlying younger rocks have been removed by weather agents, and the conglomerate thus exposed at the surface is available for 'shallow workings.' In the detritus removed from the original conglomerate and deposited in river-valleys the diamonds may be reached by superficial, shallow, or comparatively deep workings, and they may be all spoken of conveniently as 'alluvial workings.'

Production.

The figures returned for diamonds relate to the production in the Central Indian States of Panna, Charkhari and Ajaigarh, with the addition of Bijawar and Baraunda. The production during the five years under review is

shown in Table 35, the average being 161·94 carats worth Rs. 92,124 as compared with 42·57 carats worth Rs. 18,240 during the previous five years.

TABLE 35.—*Production of Diamonds in Central India during the years 1919 to 1923.*

YEAR.	CENTRAL INDIA.		
	Quantity.	Value.	Daily labour.
	Carats.	Rs.	Persons.
1919	311·90	2,08,253	2,857
1920	85·10	41,252	736
1921	126·11	72,970	888
1922	171·39	91,648	914
1923	115·22	46,495	549
AVERAGE .	161·94	92,124	1,189

Although no official returns are available, private but unconfirmed reports indicate that every year a certain number of valuable diamonds are picked up after showers of rain in the neighourhood of Wajra Karur in the Anantapur district of the Madras Presidency. One was recently found in a field north of the pipe, calculated of sufficient size to yield a table diamond of sixty carats worth about a lakh of rupees.

During 1910-12, Mr. A. Ghose prospected a concession at Viraypalle in the Karnul district. The bed of diamond-bearing conglomerate was found to vary between 3 inches and 2 feet in thickness and to yield from $\frac{1}{5}$ to $\frac{1}{2}$ carat of diamond from each load of 16 cubic feet, most of the diamonds obtained being perfect crystals of fine quality and free from flaws. During the past ten years no returns of the output in Madras have been forthcoming, and the working of the mines appears to have been suspended.

Gold.[1]

[E. H. PASCOE.]

The production of gold in the world during the year 1922 is valued at about 72 millions sterling. Thus India with a production

[1] A general account of the gold occurrences of India and Burma is given in Dr. Maclaren's "Gold," pp. 238-270 (1908); considerable use has been made of this in preparing this article.

of £1,857,577 in that year contributed only 3 per cent. of the total. During the four years 1904 to 1907 India occupied the seventh position amongst the leading gold producing countries of the world; in 1908 she fell to the eighth, but regained her old position in 1917; in 1921 she fell again to the eighth place according to figures from America. From the same authority she maintained this position during 1922 (see Table 36).

TABLE 36.—*Values of the Gold produced by the chief gold-producing countries during 1922*[1].

Countries.	Value.
	£
1. Transvaal	32,710,384
2. United States	11,026,862
3. Canada	5,895,259
4. Australasia	4,248,081
5. Mexico	3,491,873
6. South America	3,467,269
7. Rhodesia	3,057,788
8. India	1,857,577
9. Japan and Chosen	1,681,038
10. West Africa	1,035,892
11. Russia including Siberia	683,747
12. Other Countries	2,699,999
TOTAL	71,855,769

Provincial production.

Table 37 shows the provincial production for India during the five years under review. In 1904 no less than 98·2 per cent. (by value) of the Indian output was returned by Mysore, and 1·7 per cent. by the Nizam's Dominions, leaving only 0·1 per cent. as the produce of districts directly under British administration. By 1908, owing to the development of reef mining in Dharwar and of dredging in Myitkyina, the proportion derived from districts directly under British administration had risen to 2·7 per cent.; of the remainder, 94·4 per cent. came from Mysore and 2·9 per cent. from the Nizam's Dominions During the period under review Mysore has easily

[1]Figures taken from *The Mineral Industry for 1923.*

TABLE 37.—*Quantity and value of Gold produced in India during the years 1919 to 1923.*

PROVINCE.	1919.		1920.		1921.		1922.		1923.	
	Quantity.	*Value*	Quantity.	*Value.*	Quantity.	*Value*	Quantity.	*Value.*	Quantity.	*Value.*
	Oz.	*Rs.*	Oz	*Rs.*	Oz.	*Rs*	Oz.	*Rs.*	Oz.	*Rs.*
Bihar and Orissa.										
Singhbhum .	173	*11,776*	..	..	..	..	..	..	..	..
Burma.										
Katha . .	7·79	*440*	3·04	*2[illegible]2*	15·66	*927*	12·01	*815*	23·46	*1,672*
Upper Chindwin	30·84	*2,981*	7·69	*717*	26·50	*3,115*	12·0	*1,280*	44·30	*4,134*
Hyderabad .	10,647·6	*6,10,196*	12,390	*5,88,695*	..	..	..	..	..	..
Madras . .	(*a*)11,018	*6,16,934*	(*a*) 13,645	*8,03,535*	(*a*)10,108	*7,21,359*	(*a*)8,388	*6,08,673*	(*a*)1,519	*1,01,016*
Mysore . .	485,248	*2,32,17,075*	482,958	*2,[illegible]9,33,544*	(*b*)422,533	*3,00,30,373*	(*c*)429,550·6	*2,72,50,073*	(*d*)419,667·64	*2,53,69,141*
									(*e*)1,001·46	*60,690*
Punjab . .	130·73	*8,914*	61·18	*4,274*	39·43	*2,853*	40·8	*2,638*	48·8	*2,860*
United Provinces	4·6	*321*	2·7	*191*		..	2·63	*175*	1·9	*125*
TOTAL	**507,260·56**	*2,44,[illegible]8,639*	**499,067·61**	*2,73,31,158*	**432,722,59**	*3,07,58,627*	**438,015·04**	*2,78,63,654*	**422,306·56**	*2,55,39,638*
Value in sterling		*£2,127,705* (£1=Rs. 11·5)		*£2,733 115* (£1=Rs. 10)		*£2,050,575* (£1=Rs. 15)		*£1,857,577* (£1=Rs. 15)		*£1,702,642* (£1=Rs. 15)

(*a*) Fine Gold.
(*b*) Contains 380,780·49 oz. fine gold.
(*c*) Contains 381,955·18 oz. fine gold including 3,172·24 oz. obtained from cyanide slags
(*d*) Contains 381,058·93 oz. fine gold.
(*e*) Fine gold obtained from cyanide slags.

maintained its lead and in 1923 produced 99·6 per cent. of the total. The returns from Bombay (Dharwar) are blank, while the annual production from Madras has averaged 8,936 oz. The operation of the mines in Hyderabad has ceased since 1921. There was no output from Myitkyina.

Vein gold: development of the Kolar field.

The production of the Mysore State is solely derived from the Kolar district and from a single vein or reef in that district—a reef averaging only some four feet in thickness and payably auriferous for a distance of little more than four miles. As has been the case with all other known auriferous deposits in Peninsular India, the attention of Europeans was directed to this vein by the numerous old native workings along its strike. During the Wynaad gold "boom" of 1878-82, several companies with large capitals were floated to work portions of a concession over the Kolar field. Of the capital subscribed, the greater portion was devoted to purchase money and comparatively little was left for working capital. The features of the auriferous deposits were not at first grasped and much money was wasted in mining in barren ground and amidst ancient workings, which were eventually found to reach to a depth of 300 feet. All the companies, floated with such extravagant hopes in 1881-82, were moribund in 1885. and it was only a dying effort of the Mysore Company in that year that disclosed the great richness of the reef and incidentally the disposition of the auriferous chutes.

By 1887, the adjacent companies had resumed operations and from that time up till 1905, the history of the field was one of uninterrupted progress and success. During the years 1906-08, there was a fall in the output owing to zones of lower grade ore having been reached; the grade subsequently improved locally at greater depth and it was hoped that this improvement would extend to all the deep mines. It is contended by some mining engineers of considerable experience that, as a general rule, the grade of an ore does not improve in depth below certain limits, and T. A. Rickard quotes figures to show that the Kolar ores have become poorer at great depths. The deepest mines are Champion Reef and Ooregum which have each reached a depth of considerably over 6,000 feet measured vertically, and at these levels quartz has been met with just as rich as at any of the higher levels of these same mines, somewhat discounting the above contention. The figures, which are given below

are said to represent the yield in pennyweights of fine gold per short ton of the four chief mines in the years 1889 and 1913, respectively:—

—	1899.	1913.
Mysore	27·68	14·29
Champion Reef	26·41	10·92
Nundydroog	19·60	15·95
Ooregum	14·40	13·92

Of late years, much trouble and many accidents have been caused by rockbursts underground. The Champion Reef Mine has suffered from them very severely in its main shafts below the 40th level and in it concrete linings are now being substituted for timber sets. In the stoping sections, ordinary heavy timbering and filling with waste rock have to a certain extent given place to packed pig-stye sets and pack-walls, in spite of the steep inclination (between 70° and 80° from horizontal) of the lode in some of the mines.

Owing to the great depth of the mines and the high rock temperatures—117° F. in the bottom workings—the problem of ventilation has been an extremely difficult one. It has been partly solved by sinking deep circular brick-lined shafts, 18 feet in diameter, from the surface and by the use of large electrically driven fans to help the main air current and smaller fans and blowers for special places. There are 5 of these brick-lined shafts on the field of which the one on the Ooregum Mine, just completed, is the deepest, *viz.*, 4,680 feet vertical. In spite of the increased volume of air, greater velocity, better circulation and decreased humidity, some of the mines are uncomfortably hot in the lower levels.

The ore is not refractory and yields its gold to a simple combination of amalgamation and cyaniding, being reduced for the most part to a state of slime.

During the five years under review, the annual tonnage crushed gradually decreased from 702,423 tons in 1919 to 650,115 tons in 1923. (These figures, returned by the Chief Inspector of Mines for Mysore, are in short tons).

In 1905, the gold yield reached a maximum value of £2,373,457, the largest ever recorded in the history of the field. Since then there has been some fluctuation in the output, although only within comparatively narrow limits; in 1923 the value of the output sank to £1,748,426. For the five years under review, the value of the gold

extracted was £9,614,737 which is less by £848,915 than the value for the preceding five years.

In 1905, the dividends paid reached their maximum value, *viz.*, £1,006,615, for the whole period of the industry; there was then a marked annual decline to £750,000 in 1912. From that date another decline commenced, the dividends paid during the five years under review being £1,387,783 as compared with £2,992,150 paid during the previous five years. For the same period, dividends have been paid by all five companies, situated on the line of the Champion Reef—the Mysore, Champion Reef, Ooregum, Nundydroog and Balaghat Companies—but Champion Reef has ceased to pay dividends since 1921. No exploratory or mining work for gold has been done by other companies on the Kolar field or elsewhere in the Mysore State during the last five years.

An important improvement scheme, making for the reduction of working expenses and consequently for the prolongation of the life of the Kolar field, was the introduction of electric power from the Cauvery Falls. This work was completed about the middle of 1902, and was designed for the conveyance of 4,000 H. P. over a double line 92 miles long. Since then, the generating plant has been increased from time to time and in 1923 supplied 145 motors aggregating 18,699 H. P. This supply is continuous, even in the years of drought, now that the Krishnaraja Sagara Dam is more or less completed.

In order to supply power for electric lighting and the driving of motors used intermittently, a company, called the Kolar Mines Power Station, Limited, was formed in 1903, the electricity to be generated by steam power. The company began to supply power at the end of 1904, and in 1923 supplied altogether, for intermittent power as well as for power for hoisting and lighting, 6,897,125 Board of Trade units.

The scheme of water-supply from the Bethamangala Tank (some 6 miles from the field), undertaken by the Mysore Government, has ensured the mines a supply of filtered water sufficient for all purposes, though recently, owing to the partial failure of successive monsoons, a serious shortage is at present being experienced. The pumping plant has lately been electrified.

Table 38 shows the various statistics of production for the Kolar field both for the period under review and for the previous quinquennium.

TABLE 38.—*Statistics of production, Kolar Gold Field.*

YEAR.	Tonnage crushed.	Value of Gold extracted. (*a*).	Dividends paid.	Royalty paid.
		£	£	£
1914	806,818	2,166,101	726,737	(*a*) 124,940
1915	798,000	2,173,066	702,115	(*a*) 123,909
1916	768,509	2,123,073	613,032	(*a*) 121,479
1917	736,069	2,066,006	577,815	(*a*) 118,626
1918	713,983	1,935,407	372,451	(*a*) 106,837
TOTAL FOR 1914-18 .	3,823,379	10,463,653	2,992,150	595,791
1919	702,423	1,866,715	196,624	98,157
1920	673,152	2,194,595	339,756	118,224
1921	641,474	2,015,568	312,098	108,581
1922	672,963	1,789,433	254,620	95,837
1923	650,115	1,748,426	284,685	94,538
TOTAL FOR 1919-23 .	3,340,127	9,614,737	1,387,783	515,337

(*a*) Amended figures.

	£
Total value of gold produced from 1882 to 1923	60,381,056
,, ,, dividends paid ,, ,, ,, . .	20,308,365
Royalty paid to Mysore Government from 1882 to 1923 inclusive	3,180,379

The work on the field is carried on by Europeans, Anglo-Indians and Indians in the following proportions, calculated from the number employed during the year 1923, the latest for which figures are available :—

European (including Italian miners)	1·7
Anglo-Indians	1·8
Indians : men	86·5
Indians : women (employed only on the surface)	6·7
Indians : children (under 12 years : employed only on the surface).	3·3

The following table indicates the risks attendant on mining in the Mysore State :—

TABLE 39.—*Fatal Accidents in Mysore Mines for the years 1919 to 1923.*

YEAR.	Number of persons employed.	Death rate per 1,000 employed.	Death rate per £100,000 worth of gold obtained.
1919	24,409	2·79	3·63
1920	23,925	3·55	4·68
1921	23,344	2·91	4·20
1922	23,297	3·09	4·44
1923	20,604	3·78	4·46
AVERAGE .	23,115	3·22	4·28

Hyderabad (Nizam's Dominions).

The only gold-field in India besides Kolar from which there had been a continuous production of vein gold during the preceding quinquennium was the Hutti field, situated on the Maski band of Dharwar schists in the Lingsagar district of the Nizam's Dominions (Hyderabad). The only company operating on this field was the Hutti (Nizam's) Gold Mines, Limited. It was an offshoot of the Hyderabad (Deccan) Company and was floated in 1901. Crushing with 10 head of stamps was commenced in 1903, with a production of 3,809 oz. of gold in that year. Since then the number of stamps has increased to 30. The average output during the period 1914-18 was 16,539 oz. valued at £63,463. During the period under review the mines were worked up to the first quarter of 1920, since when operations ceased.

In 1905 another company, known as the Topuldodi (Nizam's) Gold Mines, Limited with a capital of £90,000 was formed to take over from the Hutti Company an option held on the Topuldodi block in the Raichur district of the Nizam's Dominions. During 1908, 2,132 oz. of gold, worth £8,319, were produced. But as the

ore developed in the mine proved to be of very low grade, the mine was closed down, and its assets transferred to the Hutti Company.

The Dharwar Gold-field.

A third Indian field on which work was actively prosecuted during the earlier part of the period 1909-13 is the Dharwar field, situated on the Gadag band of Dharwar schists, partly in the Dharwar district and partly in the Sangli State, both of which lie in the Bombay Presidency. In spite of the expenditure of much capital in very thorough development operations the reefs were found too poor to work and the mines were abandoned in 1911.

Anantapur.

In 1902 Mr. E. W. Wetherell, of the Mysore Geological Department, discovered a previously unknown belt of Dharwar schists stretching in a north and south direction for some 32 miles through the Anantapur district of Madras, but just touching the north-east corner of the Pavagada taluk of the Tumkur district of Mysore. Several large quartz reefs occur in this belt, and near the village of Ramgiri old gold workings were found. The gold occurs in quartz veins principally in chloritic and argillaceous schists. A company, called the Anantapur Gold Field, Limited, was formed in 1905. In 1908 it transferred a portion of its holdings (the Buruju block) to a new company, the North Anantapur Gold Mines, Limited and other portions (South Jibutil block and, subsequently, North Jibutil block) under option to the Nundydroog Company of Mysore. The option was exercised and the Jibutil Gold Mines of Anantapur, Limited, was formed to take over the properties from the Anantapur Gold Field Company on payment of £5,000 in cash and 160,000 fully paid shares, of which 20,000 went to the Nundydroog Company. The Jibutil Gold Mines of Anantapur have ceased mining operations and terminated their lease, but this has occurred since the end of the quinquennium under review, *viz.*, in September 1924. The company carried out a considerable amount of developement work during the five years under consideration. Stoping the payable ore commenced in December 1923. Treatment is being effected at the north Anantapur Company's plant The North Anantapur Gold Mines Limited, after carrying on vigorous development work, ceased mining operations in July 1922. The mines, which are situated in the Dharmavaram taluq of Anantapur district. produced 44,678 ounces of fine gold during the five years 1919-23. The total fine gold produced since the commencement of operation

has been 136,522 ounces. As a result of prospecting operations in 1922 by this company, ancient gold workings were discovered in the Gooty Taluk of the Anantapur district some 35 miles north of the old North Anantapur Mine. Exploratory work has been and is still being carried out in this area.

The Nilgiris.

The Nilgiris, after many vicissitudes, have ceased to be a mining area; but some native workers are reported to be making a living by roughly treating the waste heaps, from which they extract a small quantity of gold.

Gold in sulphide lodes.

Besides occurring in the free state in quartz veins, as in all the areas noticed above, gold is sometimes found in sulphide lodes enclosed in the sulphide minerals. Thus, gold occurs in Sikkim among the mixed sulphide lodes (chalcopyrite, pyrite, pyrrhotite, blende, etc.), and in the copper-bearing lodes of Sleemanabad in the Jubbulpore district of the Central Provinces. Assays in the latter case have occasionally shown amounts as high as 15 dwts. per ton.

Alluvial gold.

Alluvial gold-washing is carried on in Assam, Bihar and Orissa, and many other places in British India, but from the fact that the washers invariably combine this pursuit with other occupations, and because the individual return is exceedingly small and is locally absorbed for jewellery, complete returns are not available. These, so far as they go, give little hope of the discovery of rich alluvial deposits in Peninsular India, or indeed in any part of India affected by the monsoon rains and dependent on them alone for the supply of the rivers. For concentration of gold a comparatively equable current is essential—a condition rarely obtainable in the gravel river beds of India, where alone gold would be found, for these are almost dry in the cold weather and roaring torrents in the Rains. The greater possibilities of dredging on the Irrawaddy appear to arise from the fact that the waters of that river are derived from ranges where, even in the cold weather, there is a heavy rainfall.

Assam.

In Upper Assam, tributaries such as the Subansiri, that flow from the north into the Brahmaputra, carry small quantities of gold.[1] One small bar near the mouth of the Subansiri gorge was found to contain more than 1 dwt. per cubic yard; but the quantity of gravel available was

[1] *Rec. Geol. Surv. Ind.*, XXXI, pp. 179-232 (1904).

very small. It is probable that some of the gold of this region is derived immediately from the Tipam (Siwalik) sandstones, and that the source of the gold in the Lohit branch of the Brahmaputra is to be sought in the metamorphic rocks of the Miju ranges.

Chota Nagpur.

In the Chota Nagpur division of Bihar and Orissa, alluvial gold is found widely distributed, but the gold-washing is of most importance in the Singhbhum and Manbhum districts, and is chiefly confined to the valley of the Subarnarekha ('golden-streaked') river and its tributaries. The average earnings amount to only As. 1½ to 2 a day.

The result of the work of Dr. Maclaren[1] and of other members of the Geological Survey was to show that nowhere in Chota Nagpur had gold deposits—either alluvial or vein—been found worth working on European lines. Not long ago, however, interest in that area revived and The Dalbhoom Gold and Minerals Prospecting Company, Limited, was promoted to work gold mines in Dhalbhum State. A modest output of 450 ounces was first made in 1915, but rose in 1917 to 2,462 ounces; it fell to 2,085 ounces in 1918 and to 173 ounces in 1919. The mines were finally closed down in 1920.

Burma : native gold washing.

The native gold-washing industry is carried on from year to year in several districts in Burma, usually by only a few people in each district; the number so engaged varies from year to year partly in accordance with the character of the seasons. No accurate figures of production are available. In 1919 gold was washed in the districts of Katha and Upper Chindwin. The returns for 1923 show a production of only 67·76 ounces.

Burma gold-dredging; the Irrawadi.

The gold-dredging on the upper reaches of the Irrawadi was largely due to the enterprise of Mr. W. R. Moore who, in association with Captain J. Terndrup, was granted in 1901 a five-years' license for dredging within the bed of the river for a stretch of some 120 miles from the confluence above Myitkina to the mouth of the Taiping above Bhamo. In 1904 the license was extended for a period of thirty years and restricted to about 88 miles of the river from Sinbo to the confluence, while sanction was given at the same time to transfer the concession to the Burma Gold Dredging Company, which was registered at Rangoon in 1903. In 1907 permission was given to alter the limits of the concession by exchanging 15

[1] *Rep. Geol. Surv. Ind.*, XXXI, pp. 59-91.

miles of the lower end for 10 miles along the N'mai-kha and 5 miles along the Mali-kha. Application was subsequently made for a further exchange of the Irrawadi part of the concession for 15 miles along the eastern river, N'mai-kha. This company was liquidated in 1911, and a new company formed, called the Burma Gold Dredging Company, 1911, Limited.

For the greater part of the period 1909-1913 five dredges were at work, but the results did not come up to expectations. Expenses were cut down considerably by the substitution of Kachin for Australian skilled labour, but the output was still considerably below that of 1909; this was attributed to the poor quality of the wash remaining to be worked in the bed of the river. The average annual outturn for the period 1914-18 was 1,951 oz. During the quinquennial period under review there was no production of gold as the Company had closed down dredging operations altogether.

The gold-bearing alluvium is coarse gravel with the gold disseminated fairly uniformly. The average value of the gravel was about 3 grains (6 annas) per cubic yard. Small quantities of platinum and platinoid metals are recovered with the gold.

The Chindwin.

The alluvial stretches of the Chindwin river have been found to contain gold at many points, but systematic prospecting has in most cases shown them to be valueless as dredging propositions, although they are a source of income to the native gold washers.[1] A concession for 180 miles of the Lower Chindwin river, stretching from Minsin to Homalin, was granted about 1903 to the Burma Mines Development and Agency, and in 1905 transferred to the Mandalay Gold Dredging Company. A dredger was obtained, but became stranded while being towed up the Chindwin river, and no further work was attempted.

The Uyu, a tributary of the Upper Chindwin, has also been prospected for alluvial gold, but with little success so far.

The Namma.

In 1905 the Namma Gold Dredging Company, Limited, with a capital of £70,000 (£55,000 issued, of which £30,000 went to vendors) was floated in London to work two stretches of the Namma river, a tributary of the Salwin, in the Shan States. A careful preliminary investigation had indicated the existence of approximately 40,000,000 cubic yards of gravel averaging 5·43 grains of fine gold per cubic yard. A steam

[1] H. S. Bion, *Rec. Geol. Surv. Ind.*, XLIII, p. 241 (1913).

dredger was purchased and floated in a paddock on the Upper Namma, but it was then found that the deposit was unfitted for this mode of exploitation. It consists of gravel and boulders embedded in a stiff clay, hardened by calcareous tufa derived from the limestone forming the sides of the valley, and is therefore not sufficiently loose to enable the buckets of the dredger to excavate it. The venture, therefore, ended in failure.

The alluvial gold deposits of Loi Twang in the Shan States, worked by native washers, have been examined in detail by Mr. T. D. LaTouche and found to be of no commercial value.[1] Alluvial deposits examined by Dr. J. C. Brown, in Mong Long, Hsipaw State, were also found to be too poor generally to be worth exploitation, although small patches were found to contain occasionally over 9 grains of gold to the cubic yard.[2]

Other Burmese rivers to which attention has been directed by European prospectors, without any tangible results so far, are the More Chaung, Taiping, and Shweli, tributaries of the Irrawadi; the Upper Chindwin; the Salwin; and the streams of Tavoy, where gold has been found associated with tinstone.

The Central Provinces.

Alluvial gold occurs in the sands and gravels of many of the rivers and streams of the Central Provinces, particularly in those that drain down from or run over areas where the ancient crystalline and metamorphic rocks crop out. According to an "Industrial Monograph on Gold and Silverware of the Central Provinces," by H. Nunn, I.C.S., published at Allahabad in 1904, which contains also the best account yet published of the native gold-washing industry of that province, gold-washing has been carried on at various times in the following districts:—Balaghat, Bhandara, Bilaspur, Chanda. Jubbulpore, Mandla, Nagpur, Raipur, Sambalpur, and Seoni. From the report quoted it appears that in addition to the washers of auriferous sands there are people engaged in a cognate industry, consisting of the extraction of the gold and silver particles, called in England 'lemel,' from the dust of a *sunar's* shop and furnace by a two-fold process, first of actual winnowing, and then of washing in a river. The resultant gold is treated by refining processes. The persons practising this 'lemel' washing, which is recorded for the Balaghat, Bilaspur, and Hoshangabad districts, are Mahomedans, and it is

[1] *Rec. Geol. Surv Ind.*, XXXV, pp. 102—113 (1907).
[2] *Rec. Geol. Surv. Ind.*, XLII, p. 37 (1912).

desirable to distinguish their occupation from that of the gold-washers proper, although there is doubtless at times a certain overlapping of the two occupations. The gold-washers are variously known in different parts of the province as *jharas, jharias, sonjharas, sonjhirias*, and *sonzaras*. The report cited gives a full account of the methods of washing and treating the gold as practised in the Tirora tahsil of the Bhandara district. The whole gold industry of the Central Provinces, however, is small and no reliable figures for output are available. It is not likely that more than 200 ounces are won annually.

Kashmir.

Washing for alluvial gold has been practised along the valley of the Indus in the Baltistan and Ladakh divisions of Jammu and Kashmir State. In Kargil and Skardo, Baltistan, the washing of ancient gravel deposits has been carried out on quite an extensive scale, actual mining operations having been undertaken to excavate the gold-bearing bands in the old river terraces in the Dras valley. The production of gold from Kashmir in 1910 was returned as 236 oz., since when no returns have been received. A small quantity of alluvial gold is said to have been obtained formerly by Tibetans from sub-recent gravels on the Para river on the border between Rupshu and the Tibetan Province of To-tzo.[1]

Punjab.

Gold washing is carried on also in some of the Punjab rivers, especially the Indus, and the production for the quinquennium totals 321 oz., giving an average annual figure of 64 oz.

United Provinces.

In the United Provinces the industry was reported in 1904 as employing about 100 workers in the Nagina tahsil of Bijnor district, and smaller numbers in Garhwal and Naini Tal. The total reported production during the quinquennium was 11·83 oz.

Graphite.

[L. L. FERMOR.]

Mode of occurrence.

Graphite occurs in small quantities in various parts of India—in the so called khondalite series of rocks in the Vizagapatam hill-tracts and adjoining Chhattisgarh Feudatory States, in a corresponding series of rocks in

[1] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 102 (1904).

Coorg, in the Godavari district of the Madras Presidency, in the Ruby Mines district in Upper Burma, and in Travancore. It has also been discovered in Sikkim, where a graphite vein, averaging about 13 inches in thickness, was found during the prospecting operations conducted by Messrs. Burn and Company at about half a mile to the north of the road from Tsuntang and Lachen. The quality of the mineral is said to be good, large bulk samples having given a return of 93 per cent. of graphite. Other veins of graphite are known to occur in the area, but have not been examined in detail[1]. It is also found in Ajmer-Marwara (Rajputana), and that district and Kalahandi and Patna in Orissa have been responsible for a slight revival of the industry, which had died out in the year 1912; as will be seen from the table below the industry has again become dormant.

The graphite deposits of Travancore occur under conditions similar to those of Ceylon, whose rocks are but a continuation of the charnockite series and associated rocks of South India. The Ceylon graphite has been made the subject of an elaborate study by E. Weinschenk, who regards it as of igneous origin,[2] a conclusion in agreement with its occurrence in South India[3]. Small quantities of graphite have been extracted in Godavari and Vizagapatam, but formerly practically the whole of the Indian production came from Travancore, where the average output used to be about 13,000 tons annually. Owing to difficulty of working at increased depths, however, the mines were no longer found to pay and were shut down in 1912. In 1915 the impossibility of obtaining graphite from abroad threw India on to her own resources; an indigenous supply again became necessary, various known deposits were opened up and there was an output of 1,318 tons in 1916. Most of this came from Rajputana and, like the Kalahandi màterial, is derived from raw material of comparatively low grade.

Production.

The occurrence of graphite in khondalite deserves further notice. One of the most prominent components of the rock formations in the Eastern Ghats facies of rocks found in Orissa and

[1] According to a report by C. Wilkinson, communicated by the late Mr. A. Whyte of Raniganj.

[2] Die Graphitlagerstätten der Insel Ceylon. *Abhand, d. k. Bayer, Akad.*, 1901, XXI, pp. 279—335.

[3] Holland. The Charnockite Series, *Mem. Geol. Surv. Ind.*, XXVIII, p. 126 (1900); and the Sivamalai Series, *Mem. Geol. Surv. Ind.*, XXX, p. 174 (1901).

the Madras Presidency is the khondalite series, khondalite being a schist composed of quartz, sillimanite, garnet, and graphite. It is not surprising, therefore, to learn that deposits of graphite of possible economic value—bands, veins and pockets—are sometimes found in association with this series. Owing possibly to the comparatively inaccessible and undeveloped character of this part of India, only a few deposits of graphite of very moderate value have, however, hitherto been discovered—in the States of Kalahandi and Patna, with recorded occurrences in the States of Athmallik and Sonpur, but other discoveries must be expected in the future when this tract becomes better known. In Kalahandi State graphite deposits have been tound at two localities. At Koladi Ghat bands 12 to 20 inches thick have been met with in clay resulting from the decomposition of khondalite, whilst at Densurgi bands of calcareous graphite occur in a decomposed gneiss, which in its fresh condition was probably a garnet-graphite-biotite-gneiss.

Graphite deposits have also been found at Daramgarh and Domaipali in Patna State in graphite schists associated with garnetiferous gneissose schists, doubtless a variety of the khondalite series. Assays of specimens and samples from Densungi in Kalahandi and Dharapgarh Marna (2 miles west ot Patna) and Dundel in Patna State have been made with the following results :—

	Densungi.		Dharapgarh.		Marna.		Dundel.	
	1	2	3	4	5	6	7	8
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Sulphur	..	..	Trace.	..	...	..	..	..
Moisture	..	1·12	0·38	0·42	0·79	0·14	0·23	1·23
Volatile matter	0·33	3·89	0·38	0·89	0·61	2·08	2·15	3·58
Carbon dioxide	..	..	10·67	12·14	..	..	..	..
Fixed carbon (diff.)	65·22	63·12	40·95	37·00	79·91	69·67	63·70	54·73
Ash	31·21	31·87	47 69	49·55	16·69	28·11	33·87	40 47

Sample 1 was assayed in the laboratory of the Geological Survey of India, and the remainder at the Imperial Institute. The latter samples were forwarded to an expert for report on their commercial value. He reported that they had not enough binding quality to be used for the manufacture of crucibles, but that, if obtained sufficiently pure, such graphite might be used for crucibles which were subjected to one heating and then ground up and re-modelled. During the

war, however, the difficulty of obtaining graphite from abroad led to the opening up of the Kalahandi deposits by the Indian Graphite Company (Messrs. Bird & Co.). The product was transported to Bisra for treatment and there picked by hand and sorted into needle (crystalline) and amorphous varieties, crushed and sieved, and put on the market as foundry graphite in two grades, the needle variety being used for the production of the higher grade. The output from Orissa States rose from 16 tons in 1915 to 252 tons in 1916 and fell to 122 tons in 1919, and 60 tons in 1920 (from the Patna State) since when there has been no production from Orissa.

Graphite has also been recorded from Durdura in Sonpur State and from Athmallik State. No details are known as to the mode of occurrence at these two localities, but it is significant that the khondalite series is prominently represented in Athmallik and probably in eastern Sonpur.

The earlier outputs from Godavery and Vizagapatam were presumably also from the khondalite series.

In Chota Nagpur graphite has been recorded from the Palamau and Monghyr districts in graphitic schists and gneisses, but none of these occurrences has yet proved to be of economic value.

During the present period there has been a small production from the Betul district in the Central Provinces.

TABLE 40.—*Production of Graphite during the years 1919 to 1923.*

	1919.		1920.		1921.		1922.		1923.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
Bihar and Orissa—										
Bhagalpur .	..	..	..	..	1·0	*60*	..	..	..	..
Kalahandi .	100·0	*6,000*	..	..	..	..	..	..	..	..
Patna . .	21·0	*1,314*	60·0	*3,600*	..	..	..	..	..	..
Singhbhum .	.	...	0·2	15	..	...	..	..	...	...
Central Provinces—										
Betul . .	..	..	23·1	*540*	24·1	*724*	..	..	..	...
Mysore .	..	..	..	..	..	..	20	(a)	..	..
Rajputana—										
Ajmer-Merwara	5·1	*875*	16.8	*1,445*	..	..	..	..	..	..
TOTAL .	**127·0**	*8,189*	**100·1**	*5,600*	**25·1**	*784*	**20**	(a)	..	..
Value in sterling .	..	£712 (£1 = Rs.11·5)	..	£560 (£1 = Rs. 10)	..	£52 (£1 = Rs. 15)	..	(a)	..	..

(a) Not available.

Iron.

[H. C. JONES.]

Production.

Bihar and Orissa and the Central Provinces are the only provinces in India in which iron-ore is mined for the production of iron and steel by European methods. In Burma, a considerable amount of ore is won, but this is entirely for use as a flux in the Burma Corporation's lead furnaces at Namtu. Table 42 shows the annual production in Bihar and Orissa during the last fifteen years. From this it will be seen that the production suddenly increased in 1911 by nearly 300,000 tons, the output rising from 42,653 tons in the preceding year to 342,342 tons in 1911. This was due to the operations of the Tata Iron and Steel Company, whose works at Sakchi were completed towards the end of that year; large quantities of iron-ore were therefore raised from their Gurumaisani[1] deposits in Mayurbhanj State with a view to bringing the blast furnaces into operation. For the period 1911 to 1918 the yearly output of iron-ore was of the same order ot magnitude, but during the last quinquennium there has been a considerable rise. Table 41 shows the annual production of iron-ore in India, and it will be seen that there was a big rise in the output from the Central Provinces from 2,891 tons in 1922 to 24,632 tons in 1923. This was due to the fact that the Indian Iron and Steel Company, commencing smelting operations in 1922, were, owing to transport difficulties, unable to get sufficient ore from their Gua mines in Singhbhum, and accordingly obtained ore from the Central Provinces in order to keep their blast furnace going.

General character of the iron-smelting industry.

The pages of the *Records* and *Memoirs* of the Geological Survey for the past fifty years contain ample evidence of the attention that has been paid to the iron-ores of India, but it was only within the last few years that any successful attempt has been made to establish an iron and steel industry on modern lines. On the other hand, iron-smelting was at one time a widespread industry in India, and there is hardly a district away from the great alluvial

[1] "Gurumaishini," "Gurumahisani," and other spellings.

tracts of the Indus, Ganges, and Brahmaputra, in which slag-heaps are not found, for the primitive iron-smelter finds no difficulty in obtaining sufficient supplies of ore from deposits that no European iron-master would regard as worth his serious consideration. Sometimes he will break up small friable bits of quartz-iron-ore schist, concentrating the ore by winnowing the crushed materials in the wind or by washing in a stream. Sometimes he is content with ferruginous laterites, or even with the small granules formed by the concentration of the rusty cement in ancient sandstones. In ancient times the people of India seem to have acquired a fame for metallurgical skill, and the reputation of the famous *wootz* steel, which was certainly made in India long before the Christian era, has probably contributed to the general impression that the country is rich in iron-ore of a high-class type. It is true that throughout the Peninsula, which is so largely occupied by ancient crystalline rocks, quartz-hæmatite and quartz-magnetite schists are very common in the Dharwarian system, the system of rocks that, lithologically as well as stratigraphically, corresponds approximately to the Lower Huronian of America. But most of these occurrences consist of quartz and iron-ore so intimately blended that only a highly siliceous ore of a low grade can be obtained without artificial concentration. These occurrences of quartz-iron-ore schist are so common in India that newly recorded instances are generally passed over as matters of very little immediate economic interest. During the past few years, however, ore-bodies of great size and richness have been recognised in a belt running through the southern districts of Bihar and Orissa and constituting what is one of the most important groups of iron ore deposits of the world.

Attempts to introduce European processes.

Earlier attempts to introduce European processes for the manufacture of pig-iron and steel, in India, had been such conspicuous failures that there was naturally some hesitation in reposing confidence in the project launched by Messrs. Tata, Sons and Company. Perhaps the earliest attempt to introduce European processes was due to the enthusiasm of Mr. Josiah Marshall Heath of the Madras Civil Service, who, having resigned the service of the East India Company, obtained the exclusive privilege of manufacturing iron on a large scale in the Madras Presidency. In 1830, trial works were erected at Porto Novo in the South Arcot district, and were maintained by subsequent financial assistance from the

TABLE 41.—*Quantity and value of Iron-ore produced in India during the years 1919 to 1923.*

	1919.		1920.		1921.		1922.		1923.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
Bihar and Orissa . .	529,272	*7,28,771*	517,377	*10,21,081*	889,465	*18,96,366*	594,678	*14,44,146*	726,441	*17,24,332*
Burma	31,880	(*a*)*1,27,520*	37,383	(*a*)*1,49,761*	49,831	(*a*)*1,99,324*	27,680	(*a*)*1,10,720*	53,240	(*a*)*2,12,960*
Central Provinces . .	2,596	*8,716*	3,241	*10,786*	2,433	*9,925*	2,891	*11,564*	24,632	*1,08,933*
Other Provinces and States	2	(*b*)	4	(*b*)	355	*2,714*	25	(*b*)	71	(*b*)
TOTAL .	**563,750**	*8,65,007*	**558,005**	*11,81,628*	**942,084**	*21,08,329*	**625,274**	*15,66,430*	**804,384**	*20,46,225*
Total value in sterling .	..	*£75,218* (£1= Rs. 11·5)	..	*£118,163* (£1= Rs. 10)	..	*£140,555* (£1= Rs. 15)	..	£104,429 (£1= Rs. 15)	..	*£136,415* (£1= Rs. 15)

(*a*) Estimated. (*b*) Not available.

East India Company. The business was taken over in 1833 by the Porto Novo Steel and Iron Company, and additional works were started at Beypur on the Malabar Coast. Various concessions were granted to Mr. Heath and to the succeeding iron company, but in spite of these, the undertaking proved to be a failure. In 1853, a new association, known as the East India Iron Company, was started with a capital of £400,000. This company obtained various concessions from Government, and erected two blast furnaces, one in the South Arcot district and another on the Cauvery river, in the Coimbatore district. These furnaces were stopped in 1858, whilst operations at Porto Novo ceased in 1866 and at Beypur in 1867. Other attempts to introduce European processes have been made in the Birbhum district of Bengal and at Kaladhungi in Kumaon.

Bengal Iron Company.

The first scheme which proved to be a financial success is that now in operation near Barakar in Bengal. Even the Barakar Iron Works passed through various vicissitudes of fortune, and showed no signs of financial success until the agency was taken over by Messrs. Martin & Company.

TABLE 42.—*Iron-ore raised in Bengal and Bihar and Orissa during the years 1909 to 1923.*

Year.	Burdwan.	Singhbhum.	Manbhum.	Sambalpur.	Mayurbhanj.	Puri.	Total Quantity.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1909	46,623	15,215	10,132	737	..	..	72,707
1910	24,387	17,646	..	620	..	..	42,653
1911	5,456	36,276	..	610	300,000	..	342,342
1912	9,882	83,425	..	608	471,232	..	565,147
1913	8,926	98,196	..	666	247,025	..	354,813
1914	1,204	151,662	..	617	249,910	48	403,441
1915	2,243	127,040	..	386	240,269	53	369,991
1916	..	150,258	..	343	240,520	55	391,176
1917	..	184,815	..	377	195,621	..	380,813
1918	..	120,363	..	402	338,903	..	459,668
1919	..	104,728	..	945	423,599	..	529,272
1920	..	113,008	..	1,010	403,359	..	517,377
1921	..	237,173	..	797	651,495	..	889,465
1922	..	215,746	..	798	378,134	..	594,678
1923	..	218,584		632	507,225	..	726,441
Average	*14,103 (7 years)*	124,942	..	636	309,819	*52 (3 years)*	442,666

The Barakar Iron Works were taken over by the present Company in 1889 and the plant completely remodelled. During 1919 the Company changed its title from "The Bengal Iron and Steel Company, Limited," to the present form "The Bengal Iron Company, Limited," and the change was accompanied by a substantial increase in the capital. The Kulti works have five blast furnaces of which four are in operation with a daily output of 500—550 tons of pig iron. Since 1919 the manufacture of ferromanganese has been discontinued.

For the past five years the pig iron output has been as follows :—

	Tons.
1919	54,580
1920	95,585
1921	85,106
1922	88,004
1923	1,19,379

The following are the average analyses of pig iron produced :—

——	Grades 1, 2 and 3.	Grades 3 and 4.
	Per cent.	Per cent.
Graphitic Carbon	3·13	2·98
Combined Carbon	0·23	0·32
Silicon	2·25	2·00
Phosphorus	1·20	1·21
Manganese	1·40	1·13
Sulphur	0·022	0·04

The blowing engines include four Parson's turbo-blowers, one of 18,000 cubic feet per minute up to 7 lbs. pressure, two of 25,000 cubic feet up to 10 lbs. pressure, and one of 50,000 cubic feet up to 10 lbs. pressure. A fifth turbo-blower of 25,000 cubic feet per minute capacity is being installed.

The iron foundries cover an area of about 200,000 square feet and comprise pipe foundries, sleeper foundries, and a foundry

for general and special castings, the latter being specially equipped to deal with heavy castings. A large well equipped machine shop disposes of the works' repairs and machines the larger or more intricate castings. The bulk of the castings are however machined in a special shop attached to the foundry. The outturn of iron castings during the period under review was as follows :—

	Tons.
1919	22,953
1920	31,042
1921	31,796
1922	25,821
1923	33,627

The coke used is made at Kulti in four batteries each of 34 ovens. These are all of Messrs. Simon Carvès regenerative type, three being waste gas and one waste heat. The present output (1924) is 22,000 tons per month. Tar and ammonia are recovered from the waste gases, the necessary sulphuric acid for the direct recovery of ammonia being made also at the company's works at Kulti.

The coal supply is obtained from the company's collieries at Ramnagar some two miles from Kulti, and from the adjoining collieries of Noonodih and Jitpur in the Jharia field. The Jitpur colliery during the period under review has been developed and equipped to deal with an output of 1,000 tons per day, this being the average demand of the ironworks.

The limestone used as a flux is raw, and is obtained from the Bisra Lime Company and also from contractors at Paraghat and Baraduar on the Bengal Nagpur Railway. The average analysis of the stone is as follows :—

	Per cent.
Calcium carbonate	95·80
Silica	2·70
Ferric oxide and alumina	0·80
Magnesium carbonate	2·25

The site of the Barakar Ironworks was originally chosen on account of the proximity of both coal and ore deposits. The outcrop of Ironstone Shales, between the coal-bearing Barakar and

Raniganj series, stretches east and west from the works, and for many years the clay ironstone nodules from this formation constituted the only supply of ore used in the blast furnaces. The use of ore from this source has been abandoned for some years in favour of the richer ore from the Company's deposits in the Kolhan Estate, Singhbhum, and at Ghatsila in Dalbhum. The principal deposits are known as Pansira Buru and Buda Buru; they are situated respectively 12 miles and 8 miles southeast of the Manharpur station of the Bengal Nagpur Railway. The total quantity of ore in sight in these two deposits is estimated at not less than 10 million tons. The ore is generally a high grade hæmatite with an average analysis of :—

	Per cent.
Iron	64·00
Silica	2·10
Lime	0·15
Alumina	1·25
Magnesia	0·18
Manganese oxide	0·05
Sulphur	0·002
Phosphorus	0·05

A 2-foot-6-inch railway line has been constructed by the Bengal Iron Company, from Manharpur to Pansira, with a branch through the Ankua valley to Buda. An aerial ropeway, with a capacity of 40 tons hourly, transports the ore from the top of Pansira hill to the railway at the foot. A gravity incline with a capacity of 60 tons hourly transports the ore likewise from a spur of the Buda hill to the railway at the foot. The use of this ore makes the quality of the company's pig-iron equal to that of the best known imported brands. The following table shows the quantity of ore used during the period under review:—

	Statute tons.
1919	92,756
1920	155,488
1921	137,634
1922	155,059
1923	208,866

Labour. The average number of persons employed daily at the Kulti Ironworks, exclusive of labour employed by contractors, was as follows :—

1919	9,707
1920	10,546
1921	8,282
1922	8,541
1923	8,996

Contractors' labour varies in numbers, but is estimated to have been between three to four thousand.

Tata Iron and Steel Company[1].

The Tata Iron and Steel Company's works are situated at Jamshedpur (formerly the town of Sakchi) in the Singhbhum district, Bihar and Orissa, being connected by a 3-mile branch line of its own to the Bengal Nagpur Railway Company's main line running from Bombay to Calcutta, at Tatanagar Station.

Tatanagar—the Bengal Nagpur Railway station—at which all the Company's supplies are received, brings within easy reach the materials necessary for the production of iron and steel, and, with the port of Calcutta 155 miles to the east, is a convenient site for the import and export of materials.

The West Plant consists of :—

180 Evence-Coppée non-recovery coke ovens in two batteries of 44 ovens each and two batteries of 46 ovens each ; average annual production of coke 180,000 tons.

50 Koppers patent regenerative coke ovens with recovery plant : average annual production of coke 120,700 tons.

150 Wilputte coke ovens in three batteries of 50 ovens each. These ovens are equipped with up-to-date labour-saving appliances, including coal-handling machinery, belt conveyors, quenching cars, modern wharf-loading coke bunkers, etc. Average annual production of coke 550,000 tons.

The whole output of coke is used at the blast furnaces and for general purposes. The coke-oven by-products consist of sulphate

[1] For information concerning the activities of the Tata Iron and Steel Company, as well as for the summary of their prospecting operations, we are indebted to Mr. T. W. Tutwiler, General Manager of the Company.

of ammonia, coal-tar and sulphuric acid. The ammonium sulphate averages 98·04 per cent. pure salt, with 25·25 per cent. ammonia, 0·60 per cent. moisture and 0·39 per cent. acid (excess). The coal-tar, on an average, contains 1·57 per cent. ammoniacal liquor, 4·59 per cent. light oils (up to 170°C. boiling point), 5·80 per cent. carbolic oils (up to 230°C boiling point), 2·27 per cent. creosote oils (up to 270°C boiling point), 11·34 per cent. anthracene oils (up to 360°C boiling point), 10·65 per cent. naphthalene, and 46·86 per cent. pitch. The sulphuric acid produced is used in the manufacture of sulphate of ammonia, and also in the process of pickling sheets, etc.

Iron is manufactured from five blast furnaces of which the details are as follow :—

"A" blast furnace; 300 tons daily capacity; blown in December 5th, 1911.

"B" blast furnace; 300 tons daily capacity; blown in September 21st, 1912.

"E" blast furnace; 300 tons daily capacity; blown in August 27th, 1919.

"D" blast furnace; 500 tons daily capacity; blown in December 6th, 1922.

"C" blast furnace; 500 tons daily capacity; blown in January 16th, 1924.

The last two furnaces of late design, are equipped with electrically driven skip hoists, gas-washers and modern improvements, and although their capacity is rated at 500 tons per day, they are at the present time exceeding this output.

The grades of pig iron manufactured, with their average percentages of silicon, manganese, phosphorus and sulphur, are as under :—

	Silicon.	Manganese.	Phosphorus.	Sulphur.
No. 1 grade . .	2·50 and over	1·25 to 1·50	0·35 to 0·40	0·025
No. 2 „ . .	2·00 to 2·50	„	„	0·03 to 0·035
No. 3 „ . .	1·50 to 2·00	„	„	0035 to 0·05
No. 4 „ . .	1·00 to 1·50	„	„	Under 0·04
Basic „ . .	Under 1·00	„	„	Under 0·04

Part of the iron produced is transferred to the steel furnaces direct in a molten state for the making of steel, part cast in sand on the furnace beds into pig-iron, and part cast into pigs in a pig casting machine.

Ferro-manganese is also produced for the company's own requirements.

Steel is manufactured from 7 open-hearth furnaces comprising 4 furnaces of 50—55 tons capacity, and 3 furnaces of 60—65 tons capacity, molten iron being stored in a mixer of 300 tons capacity. The following are the grades of steel produced :—

——	Carbon.	Manganese.	Sulphur.	Phosphorus.
British Standard Steel for Manufacture of Rails.	0·55—0·65	0·60—0·90	0·05	0·05
British Standard Mild Steel for Structural Material and Merchant Steel.	0·24—0·28	0·55—0·75	0·06	0·06
Spring Steel . . .	0·50—0·80	0·60—0·80	0·04	0·035
Laminated Springs . .	0·30—0·50	0·50—0·70	0·04	0·04
Volute and Spiral Springs .	0·80—1·00	0·30—0·50	0·035	0·035
Low Carbon Steel (dead soft) .	0·07—0·12	0·30—0·50	0·05	0·05
Low Carbon Steel for Rivets .	0·08—0·12	0·40—0·60	0·05	0·05
Low Carbon Steel for Tin Bars	0·10—0·14	0·30—0·50	0·05	0·07
Low Carbon Steel for Bolts .	0·23—0·28	0·50—0·75	0·05	0·05
Steel for Plates :—				
¾ inch and over . .	0·22—0·26	0·50—0·70	0·05	0·05
½ ,, ,, ,, . . .	0·20—0·24	0·50—0·70	0·05	0·05
⅜ ,, ,, ,, . . .	0·18—0·22	0·50—0·70	0·05	0·05
$\frac{5}{16}$,, ,, ,, . . .	0·16—0·20	0·50—0·70	0·05	0·05
¼ ,, and under. . .	0·08—0·14	0·30—0·50	0·05	0·07

Connected with the open-hearth furnaces are 39 Morgan type gas producers with revolving automatic feed, overhead travelling

lorries and hoppers, four coal elevators, and two crushers, which produce gas for the open-hearth furnaces, the soaking pits and the 28-inch mill reheating furnaces. The coal consumption at these producers is approximately 150,000 tons per annum.

Four soaking pits situated between the steel furnaces and the rolling mills are used for reheating the ingots after being cast and prior to going to the 40-inch blooming mill, which is operated by a Galloway 3-cylinder 40-inch-by-54-inch reversing noncondensing engine (rolls 2 high, 33-inch diameter). This mill is capable of blooming 240 ingots per day, or about 750 tons.

The blooms are transferred to the heating furnaces and when reheated, are rolled into either rails or structural sections on a 28-inch, "two high" reversing mill, with 3 stands of rolls, driven by an Ehrhardt and Schmer 3-cylinder $51\frac{3}{8}$-inch-by-$51\frac{3}{8}$-inch reversing non-condensing engine. The following are the sections rolled on the 28-inch mill :—

Rails.—All sizes from 30 lbs. to 100 lbs. per yard British Standard.

Structurals—

Beams.—All sizes from 5-inch$\times$3-inch to 15-inch$\times$6-inch British Standard.

Channels.—All sizes from 6-inch$\times$3-inch to 12-inch$\times$4-inch British Standard.

Angles.—All sizes from 4-inch$\times$4-inch$\times\frac{5}{16}$-inch to 6-inch$\times$6-inch $\times\frac{3}{4}$-inch.

Rails are cut into standard lengths of 30, 33 and 36 feet and structural material into stock lengths.

Billets of different sizes, rolled in the 40-inch and 28-inch mills are used in the Bar mills, where one 16-inch and two 10-inch mills—driven by a 1,000 B. H.P. tandem compound engine, non-reversing, free exhaust rope-driven—convert them into light rails of 14-lb. to 30-lb., and into various sizes of channels, beams, tees, equal and unequal angles, squares, rounds, flats and octagons.

Adjoining the mills are the finishing departments, inspection and shipping benches.

Plates are rolled in a motor-driven 96-inch plate-mill with roughing and finishing stands, each 3 rolls high. The drive in each stand is a 2,000 H.P. motor of 200 r. p. m. This mill is equipped with hydraulic and electrically controlled tables, chain conveyors, inspection

table, rotary edge cutting shears, large hydraulic cross-cut and slitting shears, circle plate shears, castor beds, and loading docks, along with reheating furnaces (utilizing coke-oven gas), power house with motors, pumps, etc. The sizes of plates rolled are from $\frac{3}{16}$-inch to $1\frac{1}{4}$-inch in thickness as follows : 60-inch wide in $\frac{3}{16}$-inch; 72-inch wide in $\frac{1}{4}$-inch; 84-inch wide in other sizes.

Two power houses provide electric current for driving, lighting and general purposes and are equipped with machinery capable of generating 12,500 K.W. and 25,000 K.W., respectively, along with blast furnace blowers, condensing equipment, service pumps, etc. Two pumping stations deal with the water supply and are equipped with pumps of 4 million gallons capacity daily, and 120,000 gallons per minute, respectively. Water required for the works and town is pumped from the Subarnarekha river into two large storage reservoirs adjoining the works.

The Boiler Plant consists of—

24—500 H.P. Babcock and Wilcox boilers.

20—500 H.P. Wicks Vertical Tube boilers.

8—1,000 H.P. Babcock and Wilcox boilers.

For the upkeep and maintenance of the plant two foundries, two machine shops, structural shops, blacksmith shops, forge shops, welding shops, and patten shops are in operation. Government analyses and other tests are carried out in a fully equipped laboratory situated within the works. Chemical and physical laboratories have also been established by the Company for the analysing and testing of materials and production.

The transportation equipment consists of—

15 6-wheel, broad gauge locomotives with tender,

6 4-wheel, saddle tank, broad gauge locomotives,

2 narrow gauge locomotives (for hauling sand) and

12 locomotive steam cranes with rolling stock and the necessary yards.

In and around the plant the company own—

$50\frac{1}{2}$	miles	of	$5\frac{1}{2}$-foot	gauge	railway	tracks.
$1\frac{1}{4}$	,,	3	,,	,,	,,	,,
$12\frac{3}{4}$	,,	2	,,	,,	,,	,,

The following table shews the production of pig-iron, steel and ferro-manganese by the Tata Iron and Steel Company, at the West Plant during the years 1919-1923.

Year.	Pig Iron.	Steel Ingots.	Blooming Mill blooms, etc.	Ferro-Manganese.
	Tons.	Tons.	Tons.	Tons.
1919	232,368	186,902	160,154	2,650
1920	221,606	156,239	137,232	1,183
1921	281,541	182,690	158,101	3,076
1922	227,683	150,475	135,151	1,810
1923	392,135	187,974	178,987	3,506
Average .	*271,067*	*172,856*	*153,925*	2,445

Products from the 28-inch Mill.

Year.	Rails.	Beams.	Channels.	Angles.	Blooms and Billets.	TOTAL.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1919 . .	58,928	18,018	5,659	3,011	10,093	95,709
1920 . .	51,535	18,858	2,889	3,107	2,911	79,300
1921 . .	79,390	8,915	2,051	1,094	3,702	95,152
1922 . .	61,497	14,807	2,631	2,283	1,058	82,276
1923 . .	76,945	14,062	1,004	..	359	92,370
Average .	*65,659*	*14,932*	*2,847*	*1,899*	*3,625*	*88,961*

Products from the Bar Mills.

Year.	Rails.	Beams.	Channels.	Angles.	Tees.	Fish-plates.	Bars.	TOTAL.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1919 .	4,255	192	579	7,572	1,132	2,866	21,756	38,352
1920 .	4,452	296	1,453	5,939	1,468	1,967	18,347	33,922
1921 .	3,679	646	1,216	3,676	1,374	4,126	15,467	30,184
1922 .	2,089	411	1,613	3,355	1,374	2,762	17,620	29,224
1923 .	2,350	348	516	6,647	2,476	3,240	25,241	40,818
Average .	*3,365*	*379*	*1,075*	*5,438*	*1,565*	*2,992*	*19,686*	*34,500*

The East Plant includes a pig-casting machine on which molten iron from the blast furnaces is cast into pigs.

Steel is produced at a Duplex plant from two 200-ton open-hearth tilting furnaces; one 3-ton electric furnace for remelting ferro-manganese and two Bessemer converters of 20—25 tons capacity. The molten iron for these furnaces is stored in a mixer of 1,300 tons capacity.

One 40-inch reversing blooming mill (driven by a 5,600 H.P. motor) with a capacity of 600,000 tons per annum, rolls blooms for rails, slabs for plates, and billets, which are converted into bars, sheets, rounds, flats, etc., sleepers, and tin bars.

One 28-inch combination rail and structural mill (electrically driven by a 6,300 H.P. motor) rolls all sizes of rails from 30 to 100 lbs. per yard, beams up to 24-inch by 7½-inch, channels up to 15-inch by 4-inches and angles up to 8-inch by 8-inch.

There is one continuous sheet bar and billet mill, consisting of 6 stands of 24-inch and 6 stands of 18 inch (electrically driven), upon which the billets are converted into sheet bar, tin bar, sleepers, plates, and billets for the merchant mill.

There is one merchant mill, consisting of a 16-inch edging mill preceding 6 stands of continuous 14-inch mill and a cross country type 12-inch mill of two trains of 2 stands each, with an auxiliary 8-inch finishing mill for rolling rods (all electrically driven) upon which small angles, tees, and merchantable sections are rolled.

One 30-inch sheet mill, electrically driven, 15 stands comprising 4 hot mills, 9 finishing mills and 2 cold mills, roll plain and corrugated sheets; there is also a galvanizing department.

As the East Plant has not come into full operation, comprehensive tables of production are not available.

Iron-ores of Mayurbhanj State.

Although the Tata Iron and Steel Company possess slightly richer and purer ore-bodies in the Raipur district, in the Kolhan Government Estate of the Singhbhum District, and in Keonjhar State, supplies of ore are at present drawn from the deposits in Mayurbhanj, which are nearer to the site of the works and to which the Bengal-Nagpur Railway Company have built a branch line about 56 miles in length.

The occurrence of valuable iron-ore deposits in Mayurbhanj was first noticed by P. N. Bose, who mentioned the following occurrences:—

(*a*) Bamanghati sub-division—

(1) Gurumaisini Hill, over an area of 8 square miles.

(2) Near Bandgaon in Saranda-pir.

(3) Sula'pat-Badampahar range from Kondadera to Jaidhanposi, a distance of some 12 miles.

(*b*) Panchpir sub-division—

At several places from Kamdabedi and Kantikna to Thakurmunda, a distance of 25 miles.

(*c*) Mayurbhanj proper—

Simlipahar range, and the submontane tract to the east (Gurguria, Kendua and Baldia).

Subsequently, on the possibility of these ores being suitable for the proposed iron and steel works, they were re-examined by Messrs. C. P. Perin and C. M. Weld, who arranged for detailed prospecting operations after securing prospecting rights from the Maharajah. A subsequent examination of the ground by Mr. W. Selkirk having demonstrated the existence of sufficient ore to warrant operations on a large scale, a lease was granted to the company over 12 square miles on a royalty-scale that will work out to an average of 2·62*d.* per ton for the first thirty years and 5*d.* per ton for the following thirty years, on an annual output of 200,000 tons of ore.

Prospecting operations determined the existence of over a dozen considerable deposits of high-grade ore in the more accessible parts of the State (see fig. 10). Of these deposits three, namely, Gurumai-

sini, Okampad (Sulaipat), and Badampahar, so far overshadow the others that reference will be made in detail to them alone. The chief point of interest in connection with the smaller deposits is that in most cases the nature or type of occurrence is practically identical with the great deposits, they being miniature reproductions as it were of the latter. As the main work of the prospectors has been devoted to the first necessary problem of determining the superficial disposition of the richer ore-bodies little has been done so far in the way of studying the geological relations and genesis of the ores.

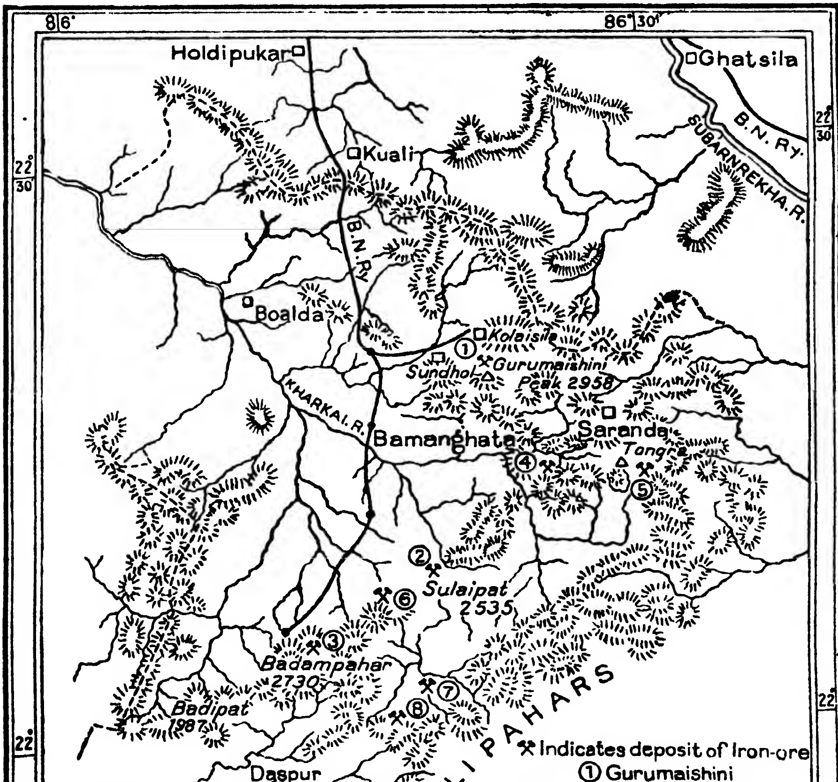

Fig. 10.—Map showing position of the Mayurbhanj iron-ore deposits.
SCALE:—1 inch = 16 miles.

The ore deposits have generally been found to have the appearance of bedded deposits of hæmatite. Occasionally small patches of magnetite occur, particularly at Badampahar. Interbedded with the ores are quartzites and shales, and the former are often closely interbanded with hæmatite, the thickness of the alternating bands of quartz and hæmatite varying from about a quarter-of-an-inch down to a mere streak. The hæmatite in this "Banded-Hæmatite-Quartzite" is not perfectly regular. It thickens or thins out, transgressing across the bands or filling up small fault fissures in the quartzite. It is considered that the ore is a metasomatic replacement of the quartzite, and the Banded Hæmatite-Quartzite an incompletely replaced deposit.

The ore is of two distinct types, one very close-grained, massive, and difficult to drill through, and the other laminated and often folded on a small scale. The former may represent altered quartzite and the latter altered shales. Both types may be of great purity, containing over 69 per cent. iron in individual samples.

Associated with the ore are granites—occasionally with graphic texture—and both the granites and the sedimentary series are cut by a network of dolerite dykes.

(1) Gurumaisini.

The Gurumaisini hill-mass, with its three prominent peaks, the highest rising to an elevation of 3,000 feet above sea level, and its numerous flanks and spurs, forms a conspicuous feature in the topography of the northern part of the State. The large bodies of iron-ore found at this point and their accessible position have combined to make it the first point of attack. In 1914-15 a careful estimate of the contents of the Mayurbhanj deposits was made by Mr. E. Curnow, and Gurumaisini was proved to contain 9,800,000 tons of ore. Since that date some 3,000,000 tons have been extracted, the average composition for the five years, 1918-22, being :—

	Per cent.
Iron	59·78
Phosphorus	0·078
Insoluble residue	5·16
Manganese	0·61

The following analyses of samples taken in the course of the several examinations to which the deposits have been subjected are also of interest:—

—	Iron.	Phosphorus.	Sulphur.	Silica.
	Per cent.	Per cent.	Per cent.	Per cent.
Average of even samples both 'solid' and 'float' ore.	61·85	0·135	0·036	4·08
Average of 20 samples of 'float' ore.	61·46	0·048	0·036	3·34
Average of ten samples of 'solid' ore.	64·33	0·075	0·021	1·64

A number of these samples were put through a complete analysis, whereby were proved the absence of titanium, chromium, zinc, nickel, cobalt (except in one case where 0·090 per cent. was found), copper, lead and baryta, and the presence of arsenic in traces only (in one case up to 0·008 per cent.).

During the five years 1918-22 the Company's supplies of iron ore were drawn mainly from this deposit, but in 1922 the mines at Sulaipat and Badampahar commenced despatching ore. The following are the tonnages despatched from 1918 onwards:—

—	Gurumaisini.	Sulaipat.	Badampahar.
1918	338,936	..	..
1919	429,873	..	..
1920	403,450	..	..
1921	438,808	..	—
1922	359,437	30,093	3,004
1923	362,782	125,831	174,634

Owing to the necessity for constantly maintaining a large and increasing output, there has been very little opportunity for any geological work to be done on the deposit. Mining has been carried on along the northern and western base of the hill for a distance

of over 2 miles. This work has shown that the lower slopes on the north and west sides of the hill are covered by a blanket of float ore ranging from 2 to 20 feet or more in thickness. This "float" rests upon a decomposed granite cut by quartz, pegmatite veins and doleritic dykes. No solid ore in place has yet been disclosed at any point in the workings, in spite of the fact that working faces have been opened up to about 400 feet above the plain level.

(2) Sulaipat.

The Sulaipat (or Okampad) ore deposit is situated just west of the Khorkai River, where the latter breaks through the Sulaipat-Badampahar range. Okampad is a conspicuous peak, only slightly lower than the Sulaipat peak (2,535 feet elevation) which lies one mile to the south-west of the former. Gurumaisini lies 12 miles to the north-north-east. A representative sample of the ore gave on partial analysis :—Fe, 63·11 ; P, 0·029 ; S. *nil* ; Ti, *nil*, per cent.

An extension of the Gurumaisini Railway was completed in 1922 to Badampahar and a narrow gauge tram-line four miles long has been built from the Sulaipat mine to a loading siding on this extension.

The ore body occurs as a single main deposit, exhibiting at one point a scarp some 200 feet high and covering a superficial area of about 56,400 square feet in plan. A smaller outlier lies to the west of this, and these two ore bodies were estimated by Mr. Curnow to contain some 2,270,000 tons of ore. The float at Sulaipat is very rich and is estimated at 936,000 tons, making a total of 3,206,000 tons for this deposit.

The intimate associates of the ore are banded hæmatite quartzite, and a dense blackish quartzite superficially resembling first grade ore and very abundant. The surrounding low-lying area is occupied by granite and both the rocks of the hill and the granite are cut by a network of dolerite dykes.

The average analysis of Sulaipat ore shipped during 1923 is as follows :—

	Per cent.
Fe	66·78
SiO_2	1·49
P.	0·044
Mn.	0·192

The last of the three major deposits occupies the Badampahar Peak (2,706 feet elevation) in the Sulaipat-Badampahar range, 8½ miles south-west from the Sulaipat ore-body. Here also as at Sulaipat and Gurumaisini, all the workings up to the present have been confined to the float ore, which is however not so continuous here as at Gurumaisini. The source of the "float" is a series of small ore-bodies capping the crests of the main hill and the spurs. The absence of continuity in these deposits is probably mainly due to faulting, but there are several quite distinct types of ore at Badampahar and the relationships of the various ore-bodies are not yet worked out. The total amount of ore at Badampahar was estimated by Mr. Curnow at 8,800,000 tons, but recent work suggests that probably 7 million tons is a more accurate estimate.

(3) Badampahar.

One very peculiar yellow ore, very light in weight and so poor in appearance that for a long time it was ignored without analysis, yielded results in certain cases as high as the following, and is now being regularly shipped :—

	Per cent.
SiO_2	0·72
Al_2O_3	0·42
Fe.	66·60
Mn.	trace.
P.	0·062
S.	0·15
TiO_2	*nil.*
Combined H_2O	2·40

The yellow colour is apparently due to the presence of limonite, but this ore in general appears to be derived from the replacement of a dolerite sill. One of the tramway cuttings has exposed an undoubted dolerite rock in which the percentage of iron varies from 26 to 37 per cent., and possibly it may prove to pass laterally into material sufficiently enriched to be worked as ore.

One of the deposits at Badampahar is magnetite. This is a small isolated solid ore-body and is in the neighbourhood of a peridotite dyke, with which it may be genetically connected. The bulk of the ore however is hæmatite of similar type to that of Gurumaisini but scarcely so rich.

The remaining associated rocks are banded hæmatite quartzites and shales similar to those at Gurumaisini and Sulaipat, with a

granite plain surrounding the area, the whole intersected by doleritic dykes. The ubiquity of these dolerites, in intimate association with the ore, suggests that the dolerites were the source of the iron which has replaced the local quartzites and shales, and at Badampahar has also replaced a dolerite sill.

Indian Iron and Steel Company.

The Indian Iron and Steel Company, Limited, was floated under the Managing Agency of Messrs. Burn & Company with a capital of Rs. 3,00,00,000 on the 11th March, 1918, for the purpose of manufacturing pig-iron, by-product coke, coal tar products, sulphate of ammonia and sulphuric acid. The Company possesses its own iron-ore, coal and limestone mines, within easy reach of the works, which latter are situated in the fork made by the Bengal-Nagpur Railway and the East Indian Railway Companies at their junction at Asansol, 132 miles north-west of Calcutta.

Blast-furnace plant.

The works consist of two 350-ton, mechanically-charged, modern furnaces with provision to increase the capacity of each furnace to 500 tons if required. The tunnel system is employed for the handling of raw material to the furnace and 75-ton capacity ladles are used for conveying the hot metal to the double-strand pig machine or to the sand-cast pig bed. All pig-iron is handled by magnets.

The Blowing Plant installed consists of two C. A. Parsons' high-pressure full-reaction type steam turbo-blowers, each with an economical output of 40,000 cubic feet of free air per minute at a pressure of 14 lbs., and a maximum output of 36,000 cubic feet of free air per minute at a pressure of 23·5 lbs.

Six blast-furnace gas-fired Babcock & Wilcox boilers, each having 4,510 square feet of heating surface and constructed for a working pressure of 200 lbs. per square inch and capable of an evaporation or 75,000 lbs. of water per hour, serve the blowing plant.

Coke-oven and by-product plant.

The coke-oven and by-product plant consists of two batteries, each of eighty Simon-Carvès horizontal-flue waste-heat ovens capable of producing 1,000 tons of coke per day. The coal-charging cars and the combined leveller and coke rams employed are electrically driven. The coke is discharged on to inclined coke cars which are hauled by electric locomotives to central quenching stations. When quenched the coke is discharged on to an inclined coke bench and fed by

means of a belt conveyor over a screening plant and discharged into railway trucks.

The direct recovery system is employed for the recovery of by-product, and a sulphuric acid plant capable of producing 18 tons of 80 per cent. acid per day from natural sulphur has been installed.

Electric power plant.

Two 3,000-K.W. Turbo Alternator sets, with the Westinghouse Rateau high-pressure type of turbine, driving the Westinghouse alternating current type of generator, are in operation and an auxiliary 150-K.W. direct current lighting set has also been installed to provide for works and bungalow lighting, should the large sets not be running. The necessary steam for driving the turbines is obtained from a battery of ten Babcock & Wilcox patent water tube boilers arranged for firing with waste heat from the coke ovens and with surplus gas. Each boiler has a heating surface of 5,246 square feet and is constructed for a working pressure of 200 lbs. per square inch.

Water supply.

The necessary circulating water for the turbo blowers, turbo alternator, blast furnace plant and the works is obtained from a large reservoir on the works area containing approximately 300,000,000 gallons of water; the make-up water for the reservoir is pumped from the Damodar River at a distance of $2\frac{1}{2}$ miles from the works by two electric pumps, each capable of pumping 60,000 gallons per hour.

The whole of the above mentioned plant is in full operation and a ready market is being found for all the Company's products.

Iron-ore mining operations.

The Company's iron-ore mine sare situated at Gua in the Kolhan Government Estate, Singhbhum. An extension of the Amda-Jamda branch of the Bengal-Nagpur Railway has been made to Gua. Considerable stocks of ore had been accumulated along an incline which had previously been installed, and when the railroad reached Gua in April 1923, despatches of ore were started at the rate of 5 to 6 hopper wagons (between 230 and 280 tons) daily, which were gradually increased to 8 and 9 as the railroad got in a better position to handle them. Ropeway materials were despatched as soon as the railroad could take delivery, and the erection of the ropeway which has always been intended for the main supply of ore was begun. Owing to the railroad banks being new, the Rains did damage to such an extent that the despatch of ore had to be stopped from August to

November, during which time the quarrying and stacking of ore was continued and the erection of the ropeway was pushed forward. In November the railroad was again opened for traffic and ore was despatched at the rate of 8 to 9 wagons daily, until about the middle of December, when the ropeway came into operation, and the output was gradually increased to 16 wagons daily, which is all the railroad can handle.

Limestone quarries.

The limestone which is used as a flux is obtained from the Company's quarries at Guttitanger and Purnapani. The construction of a branch line from the Bengal-Nagpur Railway is now in progress.

Labour at the mines.

Although there has been sufficient labour to handle the ore that the railroad can take, labour conditions have not been satisfactory owing to the use of local labour, the many local *pujahs*, rice seasons and malarious conditions.

For the above reasons it has been impossible to keep a constant number at work, and the labour force has varied as much as from 1,800 to 500 within a week's time. Labour conditions are much better now as outside labour, which is not affected by the local *pujahs* and paddy seasons, has been brought in.

Iron-ores of Singhbhum, Keonjhar and Bonai.

This most important iron-ore area in India, now being developed by the above-mentioned companies is situated some 150 to 200 miles to the west of Calcutta in the province of Bihar and Orissa and contains extremely large and rich deposits of iron-ore. They occur in the Kolhan Government Estate in the Singhbhum district, and in the Feudatory States of Keonjhar, Bonai, and Mayurbhanj. Good iron-ore is reported to occur also in the Feudatory State of Pal Lahara, and in the zamindari of Sukinda, but these two latter areas have not yet been examined. The deposits in the areas examined are remarkable for the enormous quantities of extremely rich ore they contain, and will undoubtedly prove to be amongst the largest and richest in the world.

The iron-ore usually occurs at or near the tops of hills or ranges of hills, but near Jamda in the south of the Singhbhum district, and in parts of the Keonjhar State it is often found at very low levels, and in some cases actually in the plains themselves. The most important of these ranges of hills is the one that starts near Kompilai in the Bonai State, and continues to the north-north-east

to a point about three miles south-west of Gua, a distance of about thirty miles. Running more or less parallel to this range, and possibly faulted from it, are other smaller ranges which contain good iron-ore. The main range rises some 1,500 feet above the plain, and iron-ore averaging over 60 per cent. of iron occurs for practically the whole length of the thirty miles. A few small breaks occur, where the rock has not been replaced or where folding has occurred, but these are negligible compared with the total length. The rocks forming this range dip at about 70° in a direction between north-west and west, so that the width of the outcrop of the iron-ore, which varies up to 1,000 feet, gives practically the thickness of the ore-bodies.

To the east and west of these ranges, again, are more irregular patches of ore occupying the tops of hills. Large quantities of float and lateritoid ore usually occur with the ore-bodies.

Mineralogy and nature of the ores.

Practically the whole of the ore is hæmatite and as far as is known no quantity of magnetite occurs in the ore-bodies. Small octahedral crystals occur in the ore occasionally, but they appear to be mainly martite,[1] as the rock has no appreciable effect on the magnetic needle. Small octahedral crystals, some of which are magnetite and some of which appear to be martite, occur also in the banded hæmatite-quartzite. The hæmatite is rather variable in character and the varieties may be grouped as follows:—

(1) Massive hæmatite.

(2) Laminated hæmatite.

(3) Micaceous hæmatite.

(4) Lateritic hæmatite.

(5) Hæmatite breccia.

The Kolhan hæmatites usually appear to contain about 64 per cent. of iron, with phosphorus ranging from 0·03 to 0·08, or, in some cases, to as high as 0·15 per cent. The sulphur content is usually below 0·03 per cent. Titanium in very small quantities is also said to be found occasionally in the ore. Samples from the better parts of the ore-deposits contain as much as 68 or 69 per cent. iron.

The main points of numerous analyses of these ores are the high iron content, the low percentage of sulphur and titanium, and the

[1] Registered No. L. 584, in the Geological Survey of India's collections.

variability of the phosphorus content. Manganese in any quantity seems to occur only in the lateritic variety of the ore.

Distribution and quantity of ore.

The major part of the iron-ore seems to be fairly evenly divided between the Singhbhum district, the Keonjhar State and the Bonai State. The minimum quantities estimated up to the present for ore of not less than 60 per cent. of iron are—

	Tons.
Singhbhum district	1,074,000,000
Keonjhar State	806,000,000
Bonai State	656,000,000
Disputed country (Bonai State or Keonjhar State). .	280,000,000
Mayurbhanj State	16,000,000 (?)
TOTAL .	2,832,000,000

The reported estimate of the quantities of ore in the Mayurbhanj State has not yet been verified.

From the small amount of prospecting work done by the various companies that have taken up or applied for areas, it seems possible that the solid ore may give place to the unconsolidated micaceous variety at depths of about 100 feet below the surface. The Tata Iron and Steel Company are still engaged in proving their area near Jamda.

Geology.

The rocks of the Singhbhum area are shown by Maclaren in his account of 'The Auriferous Occurrences of Chota Nagpur, Bengal,' as Dharwars (*Rec. Geol. Surv. Ind.*, Vol. XXXI). The metamorphism is, however, very much less than one expects to find in Dharwar rocks, and the writer of this article found undoubted proof near Jagannathpur, south of Chaibassa, that the Iron Ore series rests unconformably on upturned Dharwar schists and quartzites. The Iron Ore series is regarded as older than the Kadapahs by Mr. Dunn who has suggested a two-fold division of the Dharwars of Singhbhum into an upper or Iron Ore series and a lower series of schists and quartzites, with a marked unconformity separating the two. The Iron Ore series, would, therefore, seem to form the upper part of Fermor's group 2[1]; for though this series is certainly later than the Dharwar schists and quartzites, yet in places the lower beds of the series have been penetrated and absorbed by the granite.

The Dharwar schists and quartzites are certainly the oldest rocks recognised in the area, and after their uplift and denudation,

[1] *Proc. Asiat. Soc. Bengal*, Vol. XV, p. clxxvii.

the rocks of the Iron Ore series were laid down on them unconformably. A mass of granite was then intruded into the whole, but it seems to have raised and folded the Iron Ore series rather than penetrated them to any large extent. This was followed by a period of basic intrusions, which took the form of dykes in the granite area, and to a less extent in the Iron Ore series. There are also large quantities of interbanded basic igneous rock in the Iron Ore series, some of which appears to be contemporaneous with and some later than the series itself. Some ash beds have been found in the interbanded igneous rock. These intrusions of igneous material were accompanied or followed shortly by folding and faulting of the Iron Ore series on a very extensive scale. That there was more than one period of basic intrusion is proved by the presence of fragments of the basic rock in some of the fault breccias, with a similar basic rock acting as a cementing material to the same breccia.

Some intrusions of ultra-basic rocks into the Iron Ore series also occur.

The lower Dharwar rocks consist mainly of quartzites with hornblende, quartz and mica-schists ; the strike and dip are variable.

The Iron Ore series commences with a basal sandy conglomerate, ranging in thickness up to about 60 feet, and in places very coarse-grained ; it consists of angular and rounded pebbles of red jasper and white quartz cemented together by purple sandy material. This conglomerate is overlain by about 40 feet of purple and pale greyish limestone, which contains a considerable amount of fine-grained chloritic material along the bedding planes. This in its turn is overlain by a great thickness of shales, which are often very ferruginous and penetrated by thin veins of quartz. Above these shales come banded hæmatite-quartzites comprising bands up to about an inch in thickness of hæmatite, chert and jasper in varying proportions. In places the hæmatite-quartzites are seen to pass along the strike into good ore. Above the hæmatite-quartzites is another thick group of shales, which is also often very ferruginous. Both groups of shales contain small lenticular beds of sandstone. The hæmatite occurs as a replacement product in the banded hæmatite-quartzite, and to a much less extent in the shales above and below the quartzite.

The rocks of the Iron Ore series near the granite south of Chaibassa have a general north-north-east to south-south-west strike,

and are gently folded. Towards the west the dips become greater, and the rocks have been very much folded and faulted. This faulting is well seen near Lipunga, and a strike fault apparently runs along the whole length of the east side of the main iron-ore range. The rocks to the west of the fault have a very steep dip in a westerly direction. In the north part of the range the banded hæmatite-quartzites and the hæmatite have a general north-north-east to south-south-west strike, and dip at about 70° to the west-north-west; but towards the south the strike becomes nearly north and south with a similar dip to the west.

Iron-ores of the Drug district, Central Provinces.

The occurrence of valuable iron-ores in the Raipur district was not appreciated before Mr. P. N. Bose briefly referred to the chief deposits in a paper published in these *Records* (Vol. XX, page 671, 1887). The district having been explored again on behalf of Messrs. Tata Sons and Company, by Mr. C. M. Weld, a large area in the Dondi-Lohara *zamindari*[1] in the western part of the district was taken up under prospecting license for detailed examination. The iron-ores, on account of their resistance to weathering agents, stand up as conspicuous hillocks in the general peneplain. The most striking of these is the ridge which includes the Dhali and Rajhara hills, extending for some 20 miles in a zigzag, almost continuous line, and rising to heights of sometimes 400 feet above the general level of the flat country around. The iron-ores are associated with phyllites and are often of the usual type of banded quartz-iron-ore schists characteristic of the Dharwar system. But in places thick masses, apparently lenticular in shape, are formed of comparatively pure hæmatite, and one of these in the Rajhara hills has been subjected to very careful examination by diamond drilling. The Rajhara mass was carefully sampled across the surface at each point selected for a drill hole and the cores obtained were also analysed in lengths representing successive depths of 10 feet each from the surface, giving altogether 64 samples which were assayed for iron, phosphorus, sulphur, silica, and manganese. The average results obtained for the surface samples were as follows:—Fe, 66·35; P, 0·058; S, 0·108; SiO_2, 1·44; Mn, 0·151, per cent.; while for the cores the averages were:—Fe, 68·56; P, 0·064; S, 0·071; SiO_2, 0·71; Mn, 0·175, per cent.

[1] This portion of the Raipur district has been included in the new district of Drug formed in 1906

In this mass the prospecting operations thus proved the existence of 2½ million tons of ore carrying about 67·5 per cent. of iron and a phosphorus content only slightly below the Bessemer limit. The quantity estimated is that which may be regarded as ore in sight, while almost certainly much larger quantities may be obtained by continuation of the ore-bodies beyond their proved depth. There are other large bodies of ore in this area which have not been examined in the same detail. These masses of hæmatite include small quantities of magnetite, but separate determinations of the iron in the ferric state have not been made in order to determine the relative proportions of the two minerals.

Iron-ores of the Jubbulpore district.

In addition to the results of prospecting operations conducted for the Tata Iron and Steel Company in Mayurbhanj and the Central Provinces, valuable information has been collected by Mr. E. P. Martin and Professor H. Louis in the Jubbulpore district. Prospecting operations conducted in this area showed that while iron-ore is widely distributed and the formations in which it occurs are prominent in the district, there are no rich ore-bodies of large size that could be relied on for the output necessary to maintain an important industry, and most of the ore, being in the form of soft micaceous hæmatite, would be physically unfit in its natural condition for use in a blast furnace. Generally, also, the ores in this district contain a proportion of phosphorus too high for acid Bessemer steel.

The following analyses, extracted from Messrs. Martin and Louis' report (*Agricultural Ledger*, Calcutta, 1904, No. 3), give an idea of the nature of the ore in the principal occurrences in the Jubbulpore district :—

TABLE 43.—*Assays of Jubbulpore Iron-ores.*

——	Iron.	SiO_2.	S.	P.	Moisture.
I. *Agaria hill.* Lateritic cap covering most of the hill. 3 samples.	57·58	7·28	0·02	0·125	0·45
	56·85	8·17	0·02	0·125	0·67
	45·67	13·90	0·03	0·187	0·69
Soft micaceous hæmatitic schists. Ore-layers only. 2 samples.	60·70	7·45	0·019	0·075	0·25
	58·40	8·40	0·022	0·081	0·33
II. *Agaria ridge.* Bed of hæmatite 4 to 5 feet thick, dip. 50.°	50·07	11·37	0·036	0·074	0·44
III. *Jauli.* Soft, banded hæmatite-quartz schists. Picked samples.	64·67	3·70	0·027	0·023	0·30
	54·64	16·05	0·033	0·200	0·48
	65·50	3·37	0·032	0·110	0·33
	55·22	17·32	0·030	0·053	0·21

Near Sihora siliceous brown hæmatites were found, poorer in iron but physically more suitable for the blast furnace, and in this area there occur patches of manganiferous iron-ore. The following analyses shew the percentage composition of samples obtained at Mansakra (Silondi) near Sihora :—

——	Fe.	Mn.	SiO_2.	S.	P.	Moisture.
Wider band . . .	52·15	0·36	14·70	0·022	0·385	0·10
Narrower band . .	44·95	6·28	14·55	0·027	0·352	0·27
Manganiferous iron-ore .	24·45	21·47	19·60	0·022	0·163	0·80

Mysore.

Iron-ores are known to occur in large quantities in the Mysore State, and have been investigated by the Mysore Geological Department. We are indebted to Dr. W. F. Smeeth for the following notes :—

The ores appear to belong to various phases of the Archæan complex and to differ considerably in their modes of origin. The hæmatite ores of the Bababudan Hills are by far the most abundant and are of good quality but vary considerably in the amount of phosphorus that they contain. The following classification seems to be in accordance with the numerous observations so far recorded :—

(1) Banded ferruginous-quartz rock which occurs as a common integral component of the Dharwar schists. The banded ferruginous-quartzites are very widely distributed and vary greatly in the respective proportions of magnetite and hæmatite present. A number of samples from the scarps of the Bababudan Hills gave averages of 38 per cent. and 42 per cent. of iron, but many of the outcrops contain less. Owing to the very intimate admixture of the quartz and iron-ore grains in these rocks magnetic concentration has not proved very successful. Fine crushing is necessary but even after crushing through 60 mesh the richer concentrate (Fe-64 per cent.) contained only 25 per cent. of the iron in the rock. With stronger magnetic field between 60 and 70 per cent. of the iron can be recovered in a concentrate assaying about 60 per cent. Fe. The following analyses represent averages of a large number of samples divided for convenience into three grades. The analyses are made on dried ores, the moisture being usually under 1 per cent.

——	High grade.	Medium grade.	Low grade.
	Per cent.	Per cent.	Per cent.
Loss on ignition	5·23	8·87	10·61
SiO_2	1·12	1·96	3·62
Al_2O_3	2·36	3·60	9·42
TiO_2	Trace.	Trace.	0·20
Mn	0·10	0·13	Trace.
Fe	64·24	58·66	53·85
S	0·038	0·038	0·03
P	0·031	0·038	0·05

(2) Desilicified portions of (1) with, in some cases, addition of iron from solu tion or by metasomatic replacement of quartz and silicates. Thes form rich hæmatite and limonite ores. The banded ferruginous-quart zites are usually steeply inclined, but sometimes lie nearly horizontal This latter is the case over the eastern portion of the Bababudan Hills where these rocks form an undulating capping of from 200 t 500 feet in thickness on top of the green-stones and hornblend schists at an elevation of about 5,000 feet. In this area th banded quartzites outcrop where there are sharp local folds o crumples, or where there has been much denudation. On th more gentle dips and undulations solution of the silica has bee active and has caused the removal of the quartz to a depth c many feet. The result is the production of a more or less bande and porous layer of hæmatite ore to a variable depth—in place 10 feet and probably deeper. A sample taken to a depth (9 feet gave the following analysis :—

Moisture at 100° C=0·36 per cent.

Ore dried at 100°C.

H_2O	6·00	Fe	58·37
Fe_2O_3	82·79	P	0·057
FeO	0·54	S	0·047
MnO	0·08		
Al_2O_3	9·82		
MgO	0·26		
CaO	0·13		
SiO_2	0·77		
P_2O_5	0·13		
SO_3	0·118		
	100·638		

(3) Zones or layers of massive ore,—probably the result of the metasomatic replacement of silicates (igneous and metamorphic schists) by oxides of iron. These are either limonites or hæmatites and are sometimes associated with (1) and sometimes not. In some places they are associated with manganese-ores. Such ore-bodies have been found amongst the steeply inclined schists of the Shimoga district and also in the Chitaldroog schist belt, in both cases near or adjacent to manganese-ores. As regards quantity, there can be no doubt that a very large supply of fairly good ore can be obtained from various points on the eastern section of the Bababudan Hills, but no satisfactory estimate would be possible without extensive prospecting. Of ores containing about 64 per cent. iron a few million tons could probably be obtained, but it is questionable whether it would be worth while to pick such a high grade in iron. Of ores running about 60 per cent. iron probably some 25 to 50 million tons could be obtained in several large deposits, and of lower grade ores, down to 55 per cent. iron, the quantity might safely be put at 100 millions and probably at several times this amount.

(4) Magnetite and hæmatite lenses which appear to be of magmatic origin associated with ultra-basic rocks intrusive into the Dharwar schists. They are usually highly titaniferous.

A number of long lenticular outcrops of these iron-ores have been found in the Channagiri Taluk. The ores from a large number of outcrops have a strong family resemblance, and of the more massive varieties several hundred thousand tons are easily available. Partial analysis of a number of samples showed that the ores were all very similar, and a more complete analysis of one gave the following:—

	Per cent.
H_2O (total)	1·23
SiO_2	0·83
Fe	50·82
S	0·049
P	*Nil*
MnO	0·48
Cr_2O_3	3·09
Al_2O_3	1·79
CaO	0 72
MgO	1·58
TiO_2	11·60

The large amount of titanum spoils these ores for smelting purposes. The absence of phosphorus and the presence of chromium are features of all the samples. Some ores of this series also occur in the Nuggihalli schist belt of the Channarayapatna *taluk*, where they are closely associated with chrome ores in a series of amphibolites and peridotites.

(5) Quartz-magnetite ores, which appear to be of magmatic origin and genetically related to the charnockite series and therefore subsequent to the Dharwar schists and to the Archæan gneiss. These ores occur in the Malvalli *taluk* north of the Cauvery river, where the charnockite masses of Kollegal penetrate the older gneiss and schists in tongues and dyke-like intrusions. They are found also in parts of the Mysore district.

Numerous gradations have been observed between the normal basic charnockite and these ores, in which we get increases in the proportion of the magnetite and quartz with diminution of the felspar and ferro-magnesian constituents, and finally a rock composed essentially of quartz and magnetite with a little accessory hypersthene, amphibole, or garnet. The rock occurs in long thin lenses or dykes in the more normal charnockites or in the older gneissic complex, and the constituent minerals are usually grannular without any marked tendency to a banded arrangement.

The State iron industry on modern lines.[1]

For some time past, the Mysore Government have had under their consideration, the question of utilising the large iron ore deposits in the eastern summits of the Bababudan Hills in the Kadur district and some subsidiary deposits in the adjoining Shimoga district. The investigations made from time to time by the Mysore Geological Department in regard to the feasibility of the manufacture of iron from these deposits having yielded favourable results, the Mysore Government, in 1915, engaged the services of Mr. C. P. Perin, Consulting Expert of the Tata Iron and Steel Company, to advise and formulate a workable scheme for the manufacture of iron, by smelting the ore with the aid of charcoal to be obtained by distillation of wood from the forests of the Shimoga and Kadur districts. Mr. Perin accordingly drew up a report and, after a careful consideration of it, the Mysore Government decided in 1918 to start the manufacture of iron in the State in accordance with Mr. Perin's scheme.

The arrangements for the supply of raw materials required for the works and their transport have to be attended to by Government. The scheme is designated the Mysore Iron Works, and the management at present is subject to the control of a Board of Directors and a Chairman. The works are located at Bhadravati, on the Birur-Shimoga branch line of the Mysore State Railway. It is about 11 miles east of the town of Shimoga, well situated on the west bank of the river Bhadra. A new town laid out on up-to-date principles, has been built close to the works for the use of its employees.

Lines of steam-tramways, which run through the forests, have been constructed for the purpose of transporting raw materials to the works. One of these lines runs to Tanigobail, the lower terminal of the aerial ropeway from Kemmangundi for bringing iron ore to the works. The total length of these lines which are operating at present is 47·75 miles; a new line is under construction.

[1] Information kindly supplied by Mr. A. M. Sen, Offg. Director, Mysore Geological Department.

The main source of ore supply is the Kemmangundi ore-field situated about 2½ miles north-west of the Kalhatti bungalow on the top of the Bababudan Hills. The ore is mostly hæmatite with some limonite and is mined in open quarries. The ore from different work spots is trollied and collected in a bin placed at the upper terminal of the ropeway, wherefrom it is fed into buckets, handed down the ropeway and dumped automatically into the open bin at the lower terminal. The ropeway is about 3 miles long, and the vertical drop from the upper terminal at Kemmangundi to the railhead at Tanigobail is 2,000 feet. Its capacity is about 300 tons per day. The ropeway is expected to be completed soon.

The dolomite flux was first intended to be brought from the quarry at Voblapur in the Tumkur district. As the cost of transport was heavy, it was given up in favour of similar suitable flux which is now being mined at the newly opened up quarry on the Shankargudda range of hills in the Shimoga district and supplied to the works at less cost.

The siliceous ore required for mixing with the iron ore is being at present obtained from the quarry opened up about 3 miles west of Birur and railed on to the works at Bhadravati.

Owing to the delay experienced in completing the construction of the aerial ropeway down the slopes of the Bababudan hills and to other difficulties, it was decided to get the first supplies of iron-ore from the subsidiary deposit at Chattanhalli, wherefrom it could be readily conveyed to the works by means of the existing tram and rail lines. Accordingly quarries were opened up and the present supply of ore which is entirely limonite is being obtained from this deposit.

The wood required for making charcoal by distillation, comes entirely from jungle trees which cannot be made use of for any better purpose, and is being supplied from coupes which have been systematically laid out and worked in the State forests adjoining the works.

The works comprise smelting plant and the wood distillation with its by-product recovery plant. At present there is installed a single blast furnace of the American type with complete equipment, and it has a capacity of turning out 60 tons of pig-iron per day. The distillation plant comprises a set of ovens for burning wood in closed chambers and converting it into charcoal, and a system of pipes and apparatus designed for the recovery of the by-products, wood alcohol, acetate of lime and wood-tar. The whole scheme has cost the Government approximately Rs. 170 lakhs. All the preliminaries having been completed after a lapse of five years of construction, work was commenced in the month of January 1923, and continued to the end of the period under review. The daily output of pig-iron at present is between 40 and 45 tons, and the by-products are as follow :—

Acetate of lime	4 tons.
Alcohol	500 gallons.
Tar (settled)	3 tons.
Tar (soluble)	4 ,,
Neutral oil	35 gallons.

There being no immediate use for these products in the State, except in small quantities, the Mysore Government are obliged to dispose of them in the outside markets.

Goa and Ratnagiri.

In 1912 a visit was paid to certain iron-ore deposits being opened up by the "Compagnie des Mines de Fer de Goa" in the Portuguese territory of Goa, and by Messrs. Jambon and Company in the adjoining British district of Ratnagiri.[1] The iron-ore of these localities is of Dharwar age and crops out in the midst of laterite, and, as seen at the outcrop, is a hard ore composed either of limonite or of hæmatite containing minute crystals of magnetite. At Bicholim in Goa the principal ore band has been traced for a distance of 7 kilometres and is said to vary in width from 30 to 100 metres. Such work as had been carried out in 1912 indicated that this hard ore is probably the surface hydrated form of friable schistose micaceous hæmatite, which is found unaltered at a relatively small distance, approximately 50 feet, below the surface. On account, however, of the extent of the outcrops, the hard superficial ore is probably available in large quantities, and, as analyses indicate it to be of high grade, with a very low percentage of silica, and phosphorus below the Bessemer limit, it seems probable that Goa possesses valuable iron-ore reserves. Some of the deposits are only 4 miles from navigable water and it is therefore not impossible that the company may succeed in their project of mining iron-ore for export to Europe. The mining of the friable schistose hæmatite, when the surface ores are exhausted, will be another problem and will depend for its success on the discovery of a cheap and easy method of bagging or briquetting. The iron-ore deposits near Redi in the Ratnagiri district are very similar to those of Bicholim and may also when opened up prove to be of considerable size.

The native smelting industry.

The indigenous methods of smelting iron have been frequently described for various districts in India, and no new features in the methods have recently been noticed. The industry still persists in a few districts of Bengal and Bihar and Orissa; in the Kumaon hills; in Mysore; the districts of Malabar, Salem, and Trichinopoly of Madras; in Hyderabad; and in several States in Central India and Rajputana. The industry shows signs of greater activity in the

[1] *Rec. Geol. Surv. Ind.*, XLIII, p. 18 (1913).

Central Provinces than elsewhere, but there has been a falling off during the period under review. Returns are now only partial and have been received from only two districts. At one locality, Ghogra, in the Jubbulpore district, manganiferous iron-ore is smelted with the production of a steely iron known as *kheri*.[1]

TABLE 44.—*Number of Iron-smelting Furnaces at work in the Central Provinces during the period 1919-1923.*

—	1919.	1920.	1921.	1922.	1923.
Bilaspur	125	133	129	129	100
Drug	34	92	26	19	19
TOTAL .	159	225	155	148	119

The native smelting industry in Garhwal.

Iron-ore occurs at numerous places along the outer Himalaya, the rocks being similar lithologically to some of the Dharwars of Peninsular India. Owing to the abundance of timber and, until recently, to the absence of railway transport by which cheap foreign iron and steel have been distributed, the *lohar*, or *agaria*, as the native smelter is sometimes called, flourished to a later date than in the more accessible parts of the Peninsula, and the industry of iron-smelting still persists in a languishing condition. The necessity of curtailing the indiscriminate cutting of forests, the readiness with which a large variety of foreign implements can be obtained in the

[1] *Mem. Geol. Surv. Ind.*, XXXVII, p. 595.

bazars, and the higher wages obtainable on account of the general progress of the country have all combined to encourage the *lohar* to leave his ancestral calling for other industries, although a few workers still occupy their leisure during slack seasons in smelting, and the native-made product is preferred to foreign iron when it can be obtained readily.

In the higher parts of the Garhwal district the fuel used is the charcoal of the *buran* (rhododendron) and *ayas* (oak), while the *chir* tree (*Pinus longifolia*) is used in the lower hills. The simple 'bloomeries' used are not unlike those generally used on the plains. The purified wrought iron obtained from about one *maund* (82 lbs.) of ore weighs only about 10 lbs.; it is made up into rough implements like hoes, hammers, and crowbars.

The *lohars* of Garhwal are regarded as belonging to an upper section of the low-caste *doms*. They regard as the founder of their caste one Kaliya *lohar*, who is supposed to have supplied the Pandavas with their fighting weapons, and he is now propitiated before each smelting operation with an offer of five pieces of charcoal.

Imports.

Except for the pig-iron and steel produced at Barakar and Jamshedpur (Sakchi), and during the last year of the period under review from Burnpur, the greater part of the iron and steel used in India is imported. The steel furnaces in the Government Ordnance factories are supplied with imported and indigenous pig-iron in the proportion of two of the former to one of the latter, and also with scrap steel. All "pig" used by the East Indian Railway Works at Jamalpur during the period under review has been of Indian origin. The iron produced by primitive Indian methods probably amounts to less than 1,000 tons a year. The imports of pig-iron averaged 10,418 tons a year during the five years 1919—1923, as compared with an annual average of 23,425 tons during the preceding five years. The requirements of the country in iron and steel are indicated by the import returns summarised in Table 45. From this it will be seen that the total value of the unfinished and finished iron and steel products imported into India more than doubled in value from 1919 to 1921, but from 1922 onwards there has been a gradual decrease; the value for 1923, however, was considerably larger than at the beginning of the quinquennium. The increase in 1921 was largely due to big imports of machinery, railway plant and rolling stock to replace worn out material which it had been impossible to replace during the

TABLE 45.—*Imports into India of Iron and Steel materials during the years 1919 to 1923.*

—		1919.	1920.	1921.	1922.	1923.	*Average.*
Cutlery and hardware (*a*) .	Rs	5,69,62,350	9,36,37,580	8,46,17,142	6,30,72,156	5,19,99,881	*7,00,57,522*
Machinery and millwork (*a*)	,,	9,29,62,270	16,95,56,400	34,99,59,458	28,51,93,144	21,79,23,239	*22,31,18,902*
Railway plant and rolling stock (*a*).	,,	7,21,71,680	12,24,75,150	22,74,09,591	16,69,04,071	12,70,09,736	*14,31,94,046*
Iron bars, pig iron, etc.	,,	56,97,390	1,08,11,210	71,56,836	85,01,555	37,94,513	*71,92,301*
	Tons	15,259	37,210	29,919	50,338	22,873	*31,120*
Iron and steel beams, sheets, pillars, rivets, etc.	Rs.	13,26,60,380	21,15,67,140	19,86,63,063	15,81,88,446	14,46,81,787	*16,91,52,163*
	Tons	275,876	493,680	404,158	518,682	525,749	*443,629*
Steel bars, angles and channels, ingots, blooms, billets, etc.	Rs.	2,26,70,560	6,24,57,130	4,16,45,731	3,56,61,259	3,13,60,486	*3,87,59,033*
	Tons	58,349	195,413	150,247	204,679	207,025	*163,143*
TOTAL Value . .	Rs.	38,31,24,630	67,05,04,610	90,94,51,821	71,75,20,621	57,67,69,642	*65,14,74,267*

(*a*) Figures for quantities are not available.

war and also to quantities of machinery, etc., ordered by the numerous new companies floated during 1919 and 1920.

Jadeite.

[E. H. Pascoe.]

Exports.

The mineral jadeite, like the true jade (nephrite) with which it is often confused, is particularly prized by the Chinese, especially by carpenters and other workmen who believe that the wearing of jade bangles renders them immune to accidents. The quarrying of the mineral forms quite an important industry in Upper Burma. Some of the mineral raised passes by the overland route into southwest China (Yunnan), but most of it finds its way down to Rangoon, whence it is exported to the Straits Settlements and to Chinese ports. Table 46 shows the extent of this export trade. From this it will be seen that the average annual export during the period under review was 4,628 cwts., as compared with an average figure of 4,751 cwts. for the period of the previous review.

Prices.

The prices paid for rough stone vary too much to permit of an average figure being given; the valuation of jadestone at the mine is in fact a pure gamble, and the price varies greatly as purchases occur in quick succession. The export values declared, however, give an idea of the worth of the stone; from Table 46 it is seen that the value so determined has averaged Rs. 318·8 per cwt. during the period.

Table 46.—*Exports*[1] *of Jadestone from Burma during the years 1919-20 to 1923-24.*

Year.	Quantity.	*Value.*	Value per cwt.
	Cwts.	Rs.	Rs.
1919-20	3,821	*9,63,315*	252·1
1920-21	5,094	*18,07,284*	354·8
1921-22	5,374	*18,98,030*	353·2
1922-23	5,762	*18,72,168*	324·9
1923-24	3,088	*8,37,052*	271·1
Average	*4,628*	*14,75,576*	*318·8*

[1] Overland trade and exports *via* Rangoon combined.

under review, being an increase of about Rs. 79 per cwt. on the average price during the preceding period of five years. From 1919 to 1923 the average quantity exported shows a small decrease, which is, however, more than compensated by a rise in the quality of the stone.

Value of jade.

Amongst prehistoric relics found in various parts of the world, both nephrite and jadeite implements and ornaments are widely distributed, and an admiration for the beauty of the stone, descended from a belief in its magical properties, maintains the value of the mineral in the eyes of the Chinese, who are the chief buyers. A workman, for instance, wearing a bracelet of jade, is supposed to be immune from the danger of falling off a ladder. To the Chinese the different varieties of both minerals, and possibly some others, are known under the generic name *yu-esh.* The softer, serpentinous mineral, bowenite, passes on the North-West Frontier under the name of *sang-i-yeshm,* and though its characters are unmistakably distinct from those of nephrite and jadeite, it is evidently regarded as a poor variety of jade.

Composition.

Two distinct minerals are included in the term jadestone or jade, namely, the true *jade* or *nephrite,* which is a silicate of calcium and magnesium, $CaO.3MgO.4SiO_2$ and a member of the amphibole grôup; and *jadeite,* which is a pyroxene of the composition $Na_2O.Al_2O_3.4SiO_2$ (silicate of sodium and aluminium). They are very similar in colour and other physical properties, but jadeite is slightly the harder and considerably the heavier of the two, and is more fusible. They are prized equally by the Chinese. No jade (nephrite) of the kind that would be regarded as a marketable mineral is known in India; but a mineral, having the essential composition and approaching coarse jade in physical characters, is known in South Mirzapur.[1] True jade, however, has been largely worked in the Karakash valley in South Turkestan for many centuries.[2]

Mode of occurrence.

The only jadestone of commercial value found in the Indian Empire is the jadeite found in the basin of the Uru River, a tributary of the Chindwin, in the Mogaung sub-division of the Myitkyina district, Upper Burma. Jadeite

[1] F. R. Mallet, *Rec. Geol. Surv. Ind.*, V, p. 22 (1872).

[2] *Cf.* papers quoted by Mallet in Manual, Geology of India, Part IV, p. 85 (1887).

is now worked at three localities—Mamon, Hweka, and Tawmaw (25° 44′; 96° 14′). At *Mamon* the jadeite is found in the form of boulders in the alluvial deposits of the Uru river, and also in the bed of the river itself. At *Hweka* the mineral is found in the form of boulders in a conglomerate of Tertiary age. But the most interesting of the three occurrences is at *Tawmaw.* Here similar boulders of the stone embedded in yellow or orange coloured clay were described by W. Griffith in 1847. It was recovered from pits about 20 feet deep and yielded an annual revenue in 1836 of something like Rs. 40,000. Subsequently it was found *in situ* in this area. Dr. A. W. G. Bleeck[1] describes the jadeite of Tawmaw as occurring in a metamorphosed igneous dyke intruded into serpentine. He concludes that the jadeite is the result of the metamorphism of an albite-nepheline rock originally forming the dyke. The change would be represented chemically as follows :—

$$NaAlSiO_4 \text{ (nepheline)} + NaAlSi_3O_8 \text{ (albite)} = 2NaAlSi_2O_6 \text{ (2 jadeite)}.$$

Under certain conditions of crystallisation nepheline-albite rocks might be formed, while under conditions of high pressure, during consolidation or after, jadeite, which has a much lower molecular volume, would be produced, the residual molecule forming albite or nepheline, according to which molecule was in excess in the original magma. (The albite molecule was the one in excess; for this mineral occurs in a mixed zone of albite and jadeite on each edge of the dyke.) The serpentines form a long ridge flanked on either side by saussuritic gabbros, saussuritic glaucophane-schists and chlorite-schists. These rocks are traversed by granite and veins of quartz; all the rocks are regarded as genetically related and as the results of the differentiation of the same magma, which gave rise successively to the peridotites, gabbros, nepheline-albite (jadeite) rock, and the siliceous end-products—granite and quartz.

History of the jadeite trade.

The following notes on the history of the jadeite industry are taken from a copy of the chapter on the jade-mining industry prepared for the Myitkyina District Gazeteer by Mr. W. A. Hertz, and kindly supplied by the Government of Burma. This in its turn is largely based on a report by Mr. Warry of the Chinese Consular Service written in 1888, and is so interesting that a perusal of the full chapter in the Gazetteer[2] will

[1] *Rec. Geol. Surv. Ind.*, XXXVI, pp. 254—295 (1908).
[2] Vol. A (1912), pp. 104—119.

well repay the reader for the time spent. In the following paragraphs the term *jade* is used in its generic sense, referring in the case of Burma to jadeite.

According to Mr. Warry, jadestone or nephrite has been known in China from a period of high antiquity. It was found in Khotan and other parts of Central Asia, the most valued variety being the costly milk-white kind held in high esteem as symbolical of purity in private and official life. The discovery that green jade (jadeite) of fine quality occurs in Northern Burma was made accidentally by a small Yunnanese trader in the thirteenth century, who, to balance the load on his mule, picked up a piece of stone, which was later found to be jade of great value. For some centuries small pieces of stone found their way across the frontier, but it was not until 1784, after protracted hostilities between Burma and China, that a regular trade was opened between the two countries, and then the Chinese soon discovered the position of the jade-producing district. At the beginning of the nineteenth century the Burmese kings seem to have become aware of the importance of the jade trade and the revenue it might yield, and in 1806 a Burmese Collectorate was established at the site of what is now the town of Mogaung, which became the head of the jade trade in Burma. The Kachins, in whose country the jade deposits are situated, and who were regarded as the absolute owners of all the jade produced, brought the mineral to Mogaung, where it was sold to the Chinese. When it was ready to leave Mogaung an *ad valorem* duty of 33⅓ per cent. was levied and a permit issued. Payments were made in bar silver—at first fairly pure, but later on debased with lead (rupees did not come into general use until 1874).

The period of greatest prosperity of the jade trade was 1831-1840, during which time at least 800 Chinese and 600 Shans were annually engaged in business and labour at the mines. All the stone went by one of several routes to Yunnan-fu, then the great emporium of the jade trade, where Cantonese merchants bought the rough stone and carried it to Canton to be cut and polished. In 1841 war broke out between Great Britain and China and the hostilities at Canton soon affected the jade trade, so that the Cantonese merchants ceased to go to Yunnan-fu, to buy stone. Stocks accumulated and Yunnan traders ceased visiting the mines. The trade passed through various vicissitudes, but it was not until 1861 that it really improved again. From that date, when the first

Cantonese merchant arrived in Mandalay and made a fortune by buying up all the old stocks of jade, till now, the bulk of the stone has been carried by sea to Canton. During the ensuing years, the jade dues were sometimes collected in the orthodox way—by the Collector at Mogaung—whilst in other years the tax was farmed out; but the King of Burma, dissatisfied with the revenue thus obtained from jade, tried in some years to purchase all the material himself direct from the Kachins at the mines. In such years the Kachins, preferring the former revenue methods, curtailed the output and produced pieces of inferior quality only. The revenue accruing to the King from the jade dues varied from Rs. 10,000 per annum to Rs. 50,000, being least when the King tried to purchase the jade himself. With the British occupation of Upper Burma the tax was farmed out to Leonpin, who made himself so unpopular by his methods of collecting the tax that he was murdered at Mogaung. The first British visit to the mines was made in 1888 by Major Adamson with a column of British troops. The tax of $33\frac{1}{3}$ per cent. on output is still farmed out by Government. It is collected at Mogaung in the case of stone transported on mules *viâ* Kamaing, and at Kindat in the case of stone transported on bamboo rafts down the Uyu and Chindwin.

The amount realised on account of this farm during the period under review was Rs. 1,30,000 per annum. The farm includes also the right to collect the royalty on *amber* at 5 per cent. *ad valorem* in the Myitkyina and Upper Chindwin districts. This system is particularly pernicious and is one which readily lends itself to abuses, it being to the interest of the lessee of the royalty as well as to that of the producer to keep the returns of production as low as possible; and it is probable that much material is smuggled away, thus escaping the payment of royalty.

The official returns for jadeite are anomalous and no reliance can be placed thereon. The fact that the export values are higher than the production values is due largely to the increased value of the mineral after it has been cut, but, in spite of a considerable loss in cutting, the quantities exported are actually higher than the reported amounts produced. The jadeite mines lie in more or less unadministered territory, so that the figures for production are approximate in rather a wide sense; the export figures are a fairly reliable indication of the state of the industry.

In addition to the export duties collected by Government various dues are levied at the mines by the *Sawbwa* of Kansi, who is the headman of the jade tract.

The actual work of quarrying is carried out by the Kachins during the dry months of the year. At Tawmaw, where the rock occurring *in situ* is quarried, considerable difficulty is experienced in extracting the tough rock, and it is found necessary to resort to splitting by fire, it is said to the detriment of the stone. The use of explosives and also of pumps has been adopted, but the industry has been in a moribund condition for some time and unless steps are taken to revive it and to place it on a more satisfactory basis, it is not likely to improve.

Jadeite has been found in the Mawlu township of the Katha district, Upper Burma, and is also reported from Tibet. Jade is stated to occur in the corundum quarries of Pipra, Rewah State.

Lead and Silver.

[J. COGGIN BROWN.]

The history of the lead and silver industries in India continues to be, for all practical purposes, the record of the exploitation of the great ore deposit at Bawdwin in the Northern Shan States of Burma and the development of the metallurgical industry there. The quinquennial period 1909-13 witnessed the inauguration of these new industries with the production of 46,000 tons of lead and 400,000 ounces of silver; during the next period, 1913-18, in spite of difficulties caused by the war, 73,817 tons of lead and over 4,831,000 ounces of silver were extracted by the Burma Mines, Limited. During the period under review the amount of lead extracted has increased to 161,902 tons, valued at Rs. 5,91,74,183 and 17,639,125 ounces of silver, valued at Rs. 4,21,85,480. There has been a satisfactory annual increase in the production of each metal from 1919 to 1923. (See Table 47.)

The mine was originally worked by the Yunnanese Chinese probably for hundreds of years and abandoned by them in the sixties of last century, when their galleries reached permanent under-

ground water-level and the Mahomedan revolt in Yunnan rendered their tenure amongst the Kachin tribes insecure. Modern development commenced in 1902, after the attention of Europeans had been drawn to the vast heaps of lead slags left by the Chinese from their silver-smelting operations. In 1909 the first production of lead and silver from the old slags was made. Early mining exploitation was not encouraging but after the discovery of the remains of a large ore-body in the "Dead Chinaman" Tunnel in 1912, development has been active and successful and the many thousands of feet of driving, cross-cutting and rising have now proved the Chinaman lode to be one of the largest and richest silver-lead-zinc ore-bodies in the world.

The ore-body was originally attacked by sinking the vertical shaft in the Bawdwin valley, but once the potential riches of the deposit were realised, a commencement was made in opening up at deeper levels, by driving Tiger Tunnel from a point nearly two miles away. This is 653 feet below the zero-level at Bawdwin, is double tracked from the portal to the internal shaft and is 9 feet by 8 feet inside measurement. It corresponds to the Number 6 level of the mine and is the main haulage and drainage level. All the ore, as it is mined, is dropped to this level and hauled out by electric locomotives to the tipple plant and storage bins at Tiger Camp. Waste material for filling is obtained from the surface and passed into the slopes through special rises. The internal shafts which are in the ore-body, are used for hoisting and lowering men and supplies and, until stoping operations begin below the lowes adit, that is Tiger Tunnel, elaborate shafts and hoisting gear art not necessary. e

In 1919 the Burma Mines, Limited, which up to that time had been a London concern, was reorganized with its headquarters in Rangoon as the Burma Corporation, Limited, and this now possesses a total authorized capital of 20,000,000 shares of Rs. 10 each of which 13,541,689 shares are issued. There is also a first mortgage 8 per cent. convertible debenture issue of £1,000,000. These figures will convey some impression of the magnitude of the operations of the Corporation which it is impossible to describe adequately in the limited space available here. All that it is proposed to do indeed is to give a short account of the geological features of the ore-bodies and to refer to the main activities during the past quinquennium.

TABLE 47.—*Production of Lead and Silver from Bawdwin Ore and Slag during the years 1919 to 1923.*

	1919		1920		1921		1922		1923		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
Lead-ore .	67,816	..	128,908	..	144,089	..	172,017	..	245,892	..	151,988	..
Slag .	96	..	..	..	..	..	..	..	..	..	..	..
Gossan flux .	1,124	..	..	..	..	..	..	..	..	..	..	..
TOTAL	**69,036**	..	**128,908**	..	**144,089**	..	**172,017**	..	**245,892**	..	**151,988**	..
Lead extracted	19,090·11	*66,81,500*	23,821	*97,56,213*	33,717	*1,17,46,967*	39,214	*1,41,71,392*	46,060	*1,68,18,111*	32,380	*1,18,34,837*
Silver extracted (ounces).	2,164,854	*48,70,919*	2,869,727	*83,37,362*	3,555,021	*88,20,855*	4,205,584	*1,00,39,362*	4,843,939	*1,01,16,985*	3,527,825	*84,37,096*
Total value in Rs.	...	*1,15,52,419*	...	*1,80,93,575*	...	*2,05,67,822*	...	*2,42,10,754*	...	*2,69,35,096*	...	*2,02,71,933*
Total value in sterling	..	* *1,004,558*	..	† *£1,809,357*	..	‡ *£1,371,188*	..	‡ *£1,614,050*	..	‡ *£1,795,673*	..	*1,518,965*

* (£1 = Rs. 11·5.) † (£1 = Rs. 10.) ‡ (£1 = Rs. 15.)

TABLE 48.—*Production of Silver during 1919 to 1923.*

	1919		1920		1921		1922		1923		AVERAGE.	
	Quantity	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Ozs.	Rs.	Ozs.	Rs.	Ozs.	Rs.	Ozs.	Rs.	Ozs.	Rs.	Ozs.	Rs.
***Burma*—**												
Northern Shan States	2,164,854	*48,70,919*	2,869,727	*83,37,362*	3,555,021	*88,20,855*	4,205,584	*1,00,39,362*	4,843,939	*1,01,16,985*	3,527,825	*84,37,096*
Madras												
Anantapur .	753	*1,537*	868	*2,270*	619	*1,419*	554	*1,231*	103	*202*	579	*1,332*
***Mysore*—**												
Kolar . .	..	..	35,802	*91,460*	31,947	*72,847*	38,166	*87,911*	19,024	*40,915*	(a) 24,988	(a) *58,627*
TOTAL .	**2,165,607**	*48,72,456*	**2,906,397**	*8[illegible],31,092*	**3,587,587**	*88,95,121*	**4,244,304**	*1,01,28,504*	**4,863,066**	*1,01,58,102*	**3,553,392**	*84,97,055*
Total value in sterling.	..	*£423,692**	..	*£843,109†*	..	*£593,008‡*	..	*£675,234‡*	..	*£677,207‡*	..	*£642,450*

*(£1 = Rs. 11·5.) †(£1 = Rs. 10.) ‡(£1 = Rs. 15.)

(a) Average of five years.

Several excellent papers have appeared recently dealing with this subject and the reader desirous of following the fascinating story of the development of a great mining enterprise, the creation of a modern industrial town in the heart of the Shan jungles, 600 miles inland from Rangoon and only 40 miles from the Chinese frontier, is referred especially to an article by John W. Moule entitled "Burma Corporation, Ltd. A Description and Review of early Chinese and Present-day Operations." (*Proc. Aus. Inst. Min. Met.*, V. S. No. 46, pp. 58 to 105, 1923), to two others by A. B. Calhoun entitled "Mining Methods at Bawdwin Mine" (*Trans. Amer. Inst. Min. Met.*, Vol. LXIX, pp. 208-247, 1923) and "Bawdwin Mine in Burma" (*Eng. and Min. Journ. Press*, Vol. 113, No. 25), and to a paper by R. B. Hall entitled "Burma and Bawdwin Mines" (*Eng. Min. Journ. Press*, Vol. 115, Nos. 14, 15, 16 and 17).

We are indebted to the Burma Corporation, Limited, for the following note on the present state of the property and the progress made during the period 1919-1923.

Extensive development work has been carried out on both the Chinaman and Shan Lodes with very satisfactory results. A new feature has developed during the opening up of the Shan Lode to the north. High-grade silver-copper ore has been developed, aggregating 335,681 tons, averaging 11·1 per cent. copper and 23 oz. silver per ton. Tetrahedrite has been found on Number 5 Level of the Shan Lode, assaying silver, 57·9 oz.; lead, trace; zinc, 2·9 per cent.; copper, 26·5 per cent.

During the last year a hanging-wall ore-body 19 feet wide and 260 feet long, separated by a horse of waste from the foot-wall body, has been opened up on Number 5 and 6 Levels in the Shan Lode. This horse plays out before reaching the Number 4 Level where both bodies join. This tends to confirm the theory previously advanced that the Chinaman ore-body pitches to the north, in which case developments in the Shan Lode—its faulted section—at depth should be both interesting and favourable.

Two winzes were sunk to Number 7 Level which is now almost blocked out in the Chinaman Lode Section. The development results on this level are quite favourable both as regards area and silver lead values when compared with Number 6 Level. The area and value of the Chinaman ore-body on Number 7 Level, north of 1287

cross-cut, compare with the similar figures for Number 6 Level as follows :—

Area.	Ag. oz. per ton.	Value.		
		Pb. per cent.	Zn. per cent.	Cu. per cent.
No. 7 Level, 37,318 sq. ft. . . .	22·2	28·8	10·7	Trace
No. 6 Level, 31,952 „ . . .	24·3	30·3	13·2	0·7

Tiger Tunnel has been driven to a few hundred feet short of 2 miles from its portal at Tiger Camp and all the timbered sections replaced by masonry up to the internal shaft. It is double-tracked for over 7,700 feet and equipped with electric haulage, which conveys the ore in trains of 4-ton cars to the electrically operated tipple at Tiger Camp, whence it passes by belt conveyor to the loading bins which have a capacity of 2,500 tons.

A masonry-lined shaft 14 feet in diameter has been almost completed to Number 6 Level. This shaft will be continued to the ultimate depth of the mine and through it all ore will be raised from the lower levels to Number 6 or Tiger Tunnel level. When the circular shaft is fully equipped with skips and cages the mine will be in position to handle over 1,000 tons of ore per day.

An additional compressor has been added to the air compressing plant, the capacity of which is now 6,500 cubic feet of free air at 90 lbs. pressure.

The concentrating mill, having a capacity of 800 tons per day, was completed in 1920. It is operated by electric power generated at the hydro-electric plant at the Man-sam Falls which also provide electric power for the Corporation's other plants.

The old smelter has been entirely remodelled and now consists of—

5 Godfrey roasters.

5 primary Dwight-Lloyd sintering machines.

3 secondary Dwight-Lloyd sintering machines.

33 Huntington Heberlein pots.

5 blast furnaces and accessory blower plant.

A refinery having a capacity of 4,000 tons of refined lead and 450,000 oz. of silver per month.

A large flue and dust chamber has been completed at the smelting plant which is nearly half a mile long; its smoke outlet is 727 feet above the smelter. The smelting plant is now producing refined lead and silver, antimonial lead and copper matte, whilst the mill is producing a shipping grade of zinc concentrate.

During the year 1918 the Corporation produced 18,994·95 tons of refined lead and 1,970,614 oz. of silver, whilst during the year 1923 the figures were 44,551 tons of refined lead and 4,843,939 oz. of silver—an increase of 134·5 per cent. of lead and 145·8 per cent. of silver.

The ore reserves on December 31st, 1923 were as follows :—

	Tons.	Ag. oz. per ton.	Pb. per cent.	Zn. per cent.	Cu. per cent.
Total Chinaman Lode	4,835,646	24·5	27·6	18·2	0·5
Total Shan Lode	720,285	19·9	19·2	11·7	4·7
Grand Total before extraction .	5,555,331	23·9	26·5	17·3	1·0
Extraction	1,015,591	29·4	31·5	20·0	0·3
Ore Reserve in Mine	4,539,740	22·7	25·4	16·8	1·2
Ore Stock	12,736	24 2	21·1	13·5	1·2
Total Ore Reserve	4,552,476	22·7	25·4	16·7	1·2
Less Copper ore as at January 1st, 1922.	335,681	23·2	12·8	7·7	11·1
Lead-Zinc ore	4,216,795	22·6	26·4	17·5	0·4

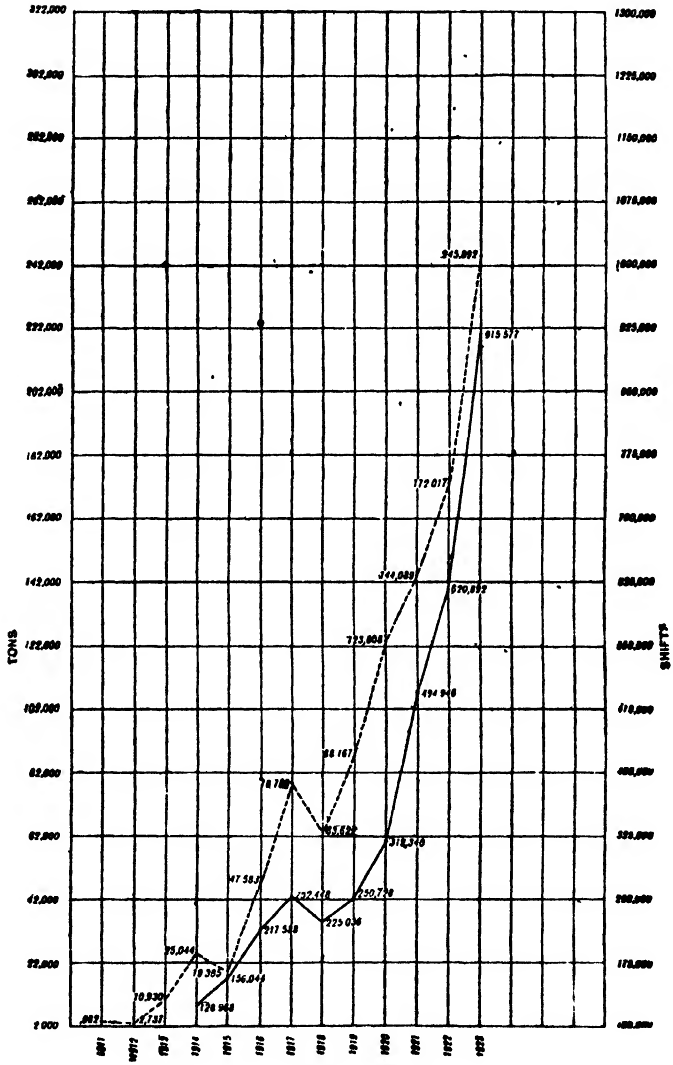

FIG. 11.—*Production of Lead-ore and number of Shifts worked in the Bawdwin mine since 1911.*

In the neighbourhood of Bawdwin an ancient series of rhyolitic tuffs, flows and breccias, with coarse felspathic grits has been intensely crushed and dislocated by overthrust faulting. The main ore channel is in this zone and ascending ore-bearing solutions have metasomatically replaced the congenial materials in the tuffs, giving rise to the sulphides themselves. The principal deposit is the Chinaman ore-body which has been developed for considerably more than 1,000 feet and varies in width from a few feet to over 100 feet, maintaining on some levels an average width of 50 feet of solid sulphides for over 1,000 feet along the strike. "It is primarily a zinc-lead-silver ore-body with small amounts of copper along the edges" writes M. H. Loveman.[1] A. B. Calhoun writes "The ore is an intimate mixture of galena and sphalerite and in many places also of chalcopyrite, although the latter is often found in parallel bands alongside the former as pure unmixed chalcopyrite. The mixture of galena and sphalerite contains approximately 1 oz. of silver for every per cent. lead."[2] To quote Mr. Loveman again, "A cross-section through the Chinaman lode shows a central core of solid zinc-lead ore, with the zinc generally, but not invariably, in excess of the lead. On both sides of this central core are alternating bands of solid ore and mineralized tuff. These bands parallel the main body in strike and dip, but are not persistent themselves, coalescing and pinching out and in reality forming a sort of stock-work. These bands are generally high in lead and comparatively low in zinc. A slight percentage of copper is generally found on their edges. From both sides of these bands the mineralization extends far out into the tuff, gradually merging into barren rock. Occasional seams and patches of ore are found at considerable distances. There is no sharp boundary between mineralized and unmineralized country rock as a general thing, although this condition is approximated in a few places by fault planes..... The extreme richness in metal content of the ore-body is best shown by the fact that a block roughly 800 feet long by 600 feet deep by 30 feet wide contains about 1,750,000 long tons with an average value of approximately Ag. 30 oz.; Pb. 31 per cent.; and Zn. 29 per cent. A theoretical block of the same size of solid galena and sphalerite with equal amounts of Pb. and Zn, would contain approximately 2,300,000

[1] *Rec. Geol. Surv. Ind.*, Vol. XLVIII, pp. 121-178 (1917); and *Trans. Amer. Inst. Min. Eng.*, Vol. LVI, p. 181 (1917).
[2] *Ibid.*, Vol. LXIX, p. 211 (1923).

long tons. Thus the block in the mine is over 75 per cent. solid lead and zinc sulphides.....A gradual thinning of the ore-body takes place on approaching the underlying sediments.[1]"

Mr. Calhoun sums up his years of experience of the Chinaman ore-body as follows :—" Taken as a whole, the southern end predominates in zinc-lead ore; the middle in more equal quantities of both; and in the northern end the zinc is partly replaced by copper. In practically all sections the ore along the hanging wall is the highest grade, with the lead predominating over the zinc, but towards the centre or the foot wall the zinc contents increase until, in many sections the zinc predominates.

" Still further toward the foot-wall the ore becomes lower grade and below what is classed as ore until it is only mineralised; the lead however predominates and is often found as pure crystals of galena. There is no definite stoping limit towards the foot-wall side, except what is arbitrarily fixed as the limit of commercial ore (20 per cent. combined lead-zinc with whatever silver it contains). Later, this arbitrary value may be lowered and another 2,000,000 tons of low grade ore added to the reserve."

The upper portion of the ore-body was largely removed by the ancient Chinese miners, and sulphides are not easily found on the surface. The gossan consists of a wide zone of soft rock stained with oxides of iron and carbonates and sulphates of copper and lead. For considerable distances it carries from 3 to 4 oz. of silver and about 5 per cent. of lead. It is quarried for use as a siliceous flux in smelting operations. A characteristic assay is as follows :--

Ag. 3 oz.: Pb. 5·8 per cent.: Zn. 0·7 per cent.: SiO_2 58·6 per cent: Fe, 11·7 per cent. The depth of the gossan is exceedingly variable, but very rarely more than 50 feet. At about this depth it is succeeded by a zone of secondary enriched copper sulphides, principally chalcocite occurring mainly as a replacement of sphalerite and some bornite. These secondary copper ores do not form a well-marked zone over the whole ore-body, but have been deposited at a few favourable places; at some points they stretch well up into the oxidised ores while at others they reach down into the normal sulphides. The secondary copper is not present in large enough quantities to be commercially important. The points at which the chalcocite occurs are about 100 feet above the present

[1] *Trans. Amer. Inst. Min. Eng.*, Vol. LVI, p. 183 (1917).

water level, but, as erosion has been severe, this horizon probably marks the water-table level at no very distant period.

The following assays show the relations between the various grades of ore that are mined :—

—	Ag. (ounces per ton).	Pb. (per cent).	Zn. (per cent.)
Silver-lead ore	47·6 54·4	50 4 50 0	19·2 24·1
High zinc ore	11·0 15 5	11·2 13·6	38·8 40·7
Zinc-lead ore	38 5	33 9	36·3
Second grade ore	11·8 18 0	22·5 20·0	7·0 12·5

Regarding the origin of the ores, M. H. Loveman has written :—" The ore-bodies at Bawdwin have been formed by the metasomatic replacement of the rhyolite tuff by sulphides deposited from hot solutions, which rose from below along an intensely crushed and sheared zone...... Whatever evidence there is, however, appears to indicate that the rhyolite is not responsible for the metal-bearing solutions."[1]

The writer of this article, working independently, concluded as a working hypothesis " that the ore-bodies at Bawdwin were formed by hot solutions from an underlying granitic magma, rising along shattered fault planes previously produced, and replacing congenial rocks, such as rhyolite tuffs whenever they happened to lie in their lines of circulation."[2]

Southern Shan States.

Small quantities of lead ore continue to be raised in the Southern Shan States. The deposits are situated in two small States of the Myelat division, have been known for many years and are now being systematically prospected by a large mining firm. The output

[1] *Trans. Amer. Inst. Min. Engr.*, Vol. LVI, pp. 191, 192.
[2] *Rec. Geol. Surv. Ind.*, XLVIII, p. 175.

of lead ore from the Southern Shan States was as follows :—

	Tons.
1919	126
1920	88
1921	138
1922	49
1923	33
TOTAL	434

Indian localities.

Previous reviews record the production of small and quite insignificant amounts of lead ore from the Drug district of the Central Provinces, from Chitaldrug in Mysore and from Kashmir. With the exception of 4 tons from the Drug district these deposits have not produced during the period under review.

Silver, Anantapur.

Silver is obtained as a by-product in the extraction of gold at the Anantapur gold mines of Madras and in the Kolar Gold-field of Mysore. Production has been as follows :—

Year.	Mysore.	Anantapur.
	Ounces	Ounces.
1919	(a)	753
1920	35,802	868
1921	31,947	619
1922	38,166	554
1923	19,024	103

(*a*) Not available.

Magnesite.

[E. H. PASCOE.]

Salem district.

The Chalk Hills lying between the town of Salem and the Shevaroy Hills in Southern India derive their name from the general effect of the network of white magnesite veins, which are prominent over an area of about 4½ square miles. The occurrence was well known early in the last century, when Mr. J. M. Heath, then 'Commercial Resident' (Collector) at Salem on behalf of the East India Company, was such an energetic prospector. The area was described by W. King and R. B.

Foote in 1864,[1] and the origin of the magnesite by alteration of dunite (olivine-rock), was first noticed in 1892.[2] A more complete account of the area with map and photographs was published in 1896 by C. S. Middlemiss,[3] who drew special attention to the large quantities of mineral easily obtainable.

Attention was again directed to the place by Mr. H. G. Turner, and through his enterprise the Magnesite Syndicate, Limited, was formed to develope the mineral. A paper by Mr. H. H. Dains[4] demonstrates the high quality of the material obtainable, the magnesite containing 96-97 per cent. of magnesium carbonate in ordinary, and 99 per cent. in picked, samples. The following analyses have been made on fair samples :—

TABLE 49.—*Analyses of Salem Magnesite.*

—	Blount.	Dains.	Pattison (cargo sample).	Ferguson.	
				1.	2.
Silica	0·22	0·29	1·17	0·31	1·70
Iron oxide	0·30	0·65	0·14	0·40	0·65
Alumina				0·10	0·10
Manganese oxide	..	0·20	0·06	..	..
Lime	*Nil.*	0·83	0·[illegible]8	..	..
Magnesium oxide	47·35	46·42	46·2	97·80	97·40
Carbon dioxide	51·44	50·71	50·1		
Water	0·27	0·16	1·[illegible]	0·60	Traces.
Sulphuric acid	..	..	0·[illegible]	..	..
Phosphoric acid	..	..	0·0	..	..
TOTAL	99·58	99·26	99·87	100·06(*a*)	99·85
Magnesium carbonate	*98·79*	*97·13*	*96·34*	*97·80*	*97·40*

(*a*) Including 0·85 calcium carbonate.

The magnesite is calcined on the spot to produce (*a*) lightly calcined or caustic magnesia, obtained at a temperature of about 800°C., and (*b*) dead-burnt, sintered, or shrunk magnesia, obtained

[1] *Mem. Geol. Surv. Ind.*, IV, pp. 312—317.

[2] T. H. Holland, *Rec. Geol. Surv. Ind.*, XXV, p. 144, footnote.

[3] *Rec. Geol. Surv. Ind.*, XXIX, p. 31.

[4] 'The Indian Magnesite Industry.' *Journ. Soc. Chem. Industry*, XXVIII, p. 503 (1909).

by calcination at about 1,700°C. The following analyses, given by Mr. Dains, represent the two products as obtained in gas-fired kilns :—

TABLE 50.—*Analyses of calcined Salem magnesite.*

—	Caustic magnesia.		Dead-burnt magnesia.
Loss on ignition	1·82	2·31	0·34
Silica	..	..	4·38
Insoluble residue	1·13	0·54	..
Ferric oxide and alumina	0·63	0·44	1·12
Lime	1·06	1·03	1·04
Magnesia	95·80	96·10	93·12
TOTAL	100·44	100·42	100·00

The following table shows the amount of magnesia manufactured during 1919 to 1923 :—

	Tons.
1919	5,884
1920	4,891
1921	6,897
1922	6,347
1923	6,746

Experiments made on a considerable scale on behalf of Mr. H. G. Turner[1] showed that when highly heated in an electric furnace the Salem magnesite yields a hard dense crystalline mass of the greatest refractory quality.

Uses of magnesite.

Magnesite has many applications, of which its use as a source of carbon dioxide and as a refractory material are amongst the most important.[2] Before the war practically the whole of the lightly calcined magnesia of Salem was shipped to Europe for use as Sorel Cement for the manufacture of artificial stone, floorings, etc. This cement is formed by mixing caustic magnesia with a solution of magnesium chloride and will carry up to 20 parts of sand for one of magnesia. During the war, however, European supplies of magnesite were not always available and in the years 1916 and 1917 large quantities were shipped to the United Kingdom from Salem. The attached table shows the Indian production during the period under review.

[1] *Journ. Iron and Steel Inst.*, No. I of 1904, pp. 498—499.
[2] *Rec. Geol. Surv. Ind.*, XXXIX, p. 126.

TABLE 51.—*Production of Magnesite during the years 1919 to 1923.*

—	1919		1920		1921		1922		1923		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
Madras—												
Salem . .	13,012	*1,56,144*	11,300	*1,35,600*	17,152	*2,05,824*	18,417	*2,21,004*	19,336	*2,32,032*	15,843	*1,90,121*
Mysore—												
Hassan . .	150	*1,500*	640·5	*7,686*	50	*500*	.	..	..	..	} 2,196	*25,667*
Mysore . .	3,964	*39,640*	2,406	*28,872*	2,815	*28,150*	856	*19,688*	100	*2,300*		
TOTAL .	17,126	*1,97,284*	14,346·5	*1,72,158*	20,017	*2,34,474*	19,273	*2,40,692*	19,436	*2,34,332*	18,039	*2,15,788*
Total value in Sterling .	..	*£17,155*	..	*£17,216*	..	*£15,632*	..	*£16,046*	..	*£15,622*	..	*£16,334*
		(£1 = Rs. 11·5.)		(£1 = Rs. 10.)		(£1 = Rs. 15.)		(£1 = Rs. 15.)		(£1 = Rs. 15.)		

Magnesite is known to occur at several other places in Southern India, always as veins traversing peridotites, for example at Seringala in Coorg, on the Cauvery above Fraserpet, in other parts of the Salem district,[1] in the Trichinopoly district, and in the Hassan and Mysore districts of Mysore.[2] In 1913, the Tata Iron and Steel Company acquired magnesite properties in the Mysore district with a view to producing refractory materials for their furnaces at Sakchi. The output in the Mysore State amounted to 4,114 tons in 1919, 3,046 tons in 1920 and 2,865 tons in 1921. Since then the production has been small, amounting to 856 tons in 1922 and 100 tons in 1923, the decrease being due to the temporary closing down of the mines worked by the Tata Iron and Steel Company, Limited. According to Mr. A. Ghose large quantities of magnesite, although of inferior quality, occur in association with the steatite deposits of Muddavaram and Musila Cheruvu in the Karnul district (see page 391).

Other occurrences.

Manganese.

[L. L. FERMOR.]

An earlier review records the rapid development of the manganese-quarrying industry in India during the early years of the present century, the zenith being reached in 1907 with an output of 902,291 tons of ore. Since 1905 the industry has maintained a position of comparative stability with an average annual production of 712,797 tons during the pre-war quinquennial period 1909 to 1913. In 1908 India took the lead amongst the world's producers of manganese-ore, hitherto held by Russia, who, however, resumed this lead in 1912 to 1915. The next quinquennial period, 1914-1918, coincided approximately with the period of the war, and was marked by controlled and restricted exports, the control being due to the necessity of ensuring that a mineral of such importance to the iron and steel industry should not reach enemy countries, either directly as ore or in the form of alloys, iron, or steel, whilst the restrictions were due to the well-known shortage of shipping. In spite of these adverse factors the Indian production during the

Progress of the Industry.

[1] W. King and R. B. Foote, *Mem. Geol. Surv. Ind.*, IV, pp. 318—324.

[2] A. Primrose, *Rec. Mysore Geol. Dept.* III, p. 239; IV, p. 178. V. S. Sambasiva Iyer, *op. cit.*, IV, p. 61. Annual Reports of the Chief Inspector of Mines in Mysore.

quinquennium 1914-1918 averaged 577,457 tons annually; but the exports for the official years 1914-15 to 1918-19 averaged only 491,558 tons, with a resultant accumulation in India during the period of over 300,000 tons of stocks, after allowing for ore railed to Sakchi and Kulti for use in the Indian iron and steel industry, this accumulation being due in part to the acute shortage of shipping during 1917 and 1918. During the post-war quinquennium, 1919-1923, the Indian production has averaged 624,635 tons annually, whilst the exports during the official years 1919-20 to 1923-24 have averaged 681,972 tons, the excess of exports over production indicating a reduction of stocks to the extent of nearly 400,000 tons during the period, after allowing for ore railed to Tatanagar, Kulti, and Burnpur for use in the iron and steel industry of India. This increase in both production and exports as compared with the war period has not, however, been due to a return to pre-war conditions, but marks the balance of beneficial factors in favour of India.

Taking the years in turn, 1919 was a year of reaction after the cessation of hostilities: both prices and freight charges fell, and although production in India showed a slight increase over that of 1918, exports of manganese-ore fell to 382,116 tons, the smallest figure recorded since 1905-06, and due in part to a shortage of wagons.

1920 was a year of rebound, characterised by increased world's steel production, a record peace-time output of ferro-manganese in the United States, with ocean freights and the price of manganese-ore per unit above the highest figures of the war period, and finally a soaring rupee. As a result the Indian production reached a figure (736,439 tons) exceeded only three times previously, and exports (1920-21) reached the then record figure of 805,839 tons (804,796 tons in 1913-14 was, perhaps significantly, the previous maximum).

The next year, 1921, was a year of world-wide trade and business depression, and the world's output of pig-iron and steel were the lowest since, respectively, 1896 and 1904, whilst the output of ferro-manganese in the United States of America was the smallest since 1911. At the same time there were enormous falls in the cost of ocean freights (from £4-9-4 to £1-5-0 for manganese-ore *ex* India to United Kingdom ports) and of the price of manganese-ore per unit (from 45·5 pence to 17·6 pence) and of the rupee-sterling exchange (from

(2*s.* $0\frac{1}{16}$*d.* to 1*s.* $4\frac{1}{32}$*d.*). These factors do not all react in the same direction on the Indian manganese industry and the result was only a small decrease in production below the figures of the previous year; the fall in exports was heavy, but still the amount was in excess of the quinquennial average for the war period, this relative maintenance of exports being due at least in part to the large producers selling a portion of their output for forward delivery.

The trade depression continued into the early part of 1922. Average freights (19*s.* 2*d.*) and price of manganese-ore (13·9 pence) fell still further, as also did exchange (to 1*s.* $3\frac{19}{32}$*d.*). But towards the end of the year there was a gradual recovery in the iron and steel industry with rising prices, which extended to manganese-ore. For the year there was a large increase in the world's output of pig-iron and steel and ferro-manganese as compared with 1921. The recovery came too late for the Indian manganese mining industry and the total output (474,401 tons) was the smallest since 1915. Accumulated stocks, however, enabled the Indian producer to take full advantage of the improved market and low freights, with the result that for the fiscal year 1922-23 the exports of manganese-ore reached the record figure of 877,194 tons.

The improvement of 1922 continued into 1923, which was one of the most prosperous years in the history of the iron and steel industry. Freights remained low, but the price of manganese-ore for the year averaged 21·2 pence, reaching 23 pence at the end of the year. Exchange rose somewhat to 1*s.* $4\frac{9}{32}$*d.* As the combined result of these factors Indian production recovered sharply to 695,055 tons, whilst the exports for the year (1923-24) were still as high as 814,342 tons. As far as the Indian manganese industry is concerned the quinquennial period closed with great activity prevalent, with many deposits of lower grade being worked at a profit, after periods of stagnation.

Russia retained her position as leading producer up to 1915: but subsequently the circumstances of war and, later, internal troubles caused the practical stoppage of the industry, so that production fell from 1,254,900 tons in 1913 to 56,200 tons in 1919, since when the industry has been slowly recovering, so that 407,401 tons were exported from Russia, including Georgia during 1923. It is reported that an American group is negotiating with the

Soviet Government for control of the Caucasian manganese-ore deposits. Such control would probably lead to less primitive methods of work than in the past, but would not necessarily be as harmful to the Indian industry as at first thought seems likely.

The disappearance of Russia from allied markets during the war was not of very serious moment to the Allies, as it coincided with the isolation of one of the chief consumers of the world's supplies of manganese-ore, namely Germany, who before the war imported large quantities from both India and Russia. Such shortage as resulted was felt chiefly in the United States, owing partly to the difficult of arranging shipping from India, and led to a great development in the manganese industry of Brazil, which, as will be seen from fig. 13, rose from third to second place amongst the world's producers, concurrently with India's resumption of first place. The exports of Brazil were taken almost entirely by the United States, not only to replace former imports from Russia and India, but also to balance a great reduction in the imports of ferro-manganese. On account, however, of the great increase in the activity of the American iron and steel industry for the provision of munitions of war, supplies of manganese-ore were still inadequate, with the result that all known occurrences of manganese-ore in the United States of America were investigated, of whatever grade, so that the output of manganese-ores containing 40 per cent manganese or over rose from 2,635 tons in 1914 to 129,405 tons in 1917, and of ores containing over 35 per cent. manganese to 305,869 tons in 1918. At the same time the output in the United States of America of ores carrying less than the above percentages of manganese rose from 98,265 long tons in 1914 to 1,170,462 long tons in 1918. To allow for the use of these lower grade ores not only was the composition of standard ferro-manganese in the States reduced from 80 per cent. to 70 per cent. manganese, but many American smelters had to adapt their practice to the use of spiegeleisen in place of ferro-manganese.

When the previous review was written it was suggested that the great increase in the American manganese industry would not prove to be permanent, as it had taken place under the stimulus of restricted supplies and high prices. This has, in fact, proved to be the case and by 1922 the output of ore carrying 35 per cent. of manganese or over fell to 13,747 tons. Nearly all the manganese-ore won in the United States of America during the war was pro-

duced at a loss, which Congress decided to make good from the War Minerals Relief Fund. To aid the American manganese industry, Congress in 1922 imposed special import duties on manganese-ore and ferro-manganese. The duty on manganese-ore is 1 cent. per lb. of metallic manganese in excess of 30 per cent, manganese contents of imported ores. This gives the heavy duty of $4·48 per ton on 50 per cent. ore. Indian producers need not, however, be alarmed at this imposition, for the careful report by a sub-committee specially appointed by the Mining and Metallurgical Society of America shows that America has only 1,400,000 tons all told of high-grade ore (41·38 per cent. Mn.), and in fact it is suggested that the only effect of this tariff will be increased costs to the American steel industry of $5,000,000 to $10,000,000 annually.[1] As anticipated in the last review, there has not been a parallel set back to the Brazilian manganese industry; and consequently a portion of the imports of the Brazilian ore into America is at the expense of India. The average annual exports of Indian ore to the United States of America before the war was 123,060 tons over a ten-year period: the average exports during the war quinquennium was 49,923 tons, whilst during the quinquennium under review it had recovered to 65,505 tons. It may, perhaps, be anticipated that with the growth of the American steel industry, India will again secure the same volume of exports to the United States.

Although the Indian manganese industry has reached a position of comparative stability, it is of course subject to variations in prosperity, as is illustrated graphically by the fluctuations in production recorded in fig. 5, page 18. On comparing this diagram with the curves of the world's production of pig-iron and steel shown in figure 12[2], it is seen that the variations in the activity of the Indian manganese industry are to be correlated with variations in the

[1] *Eng. Mining Journal-Press*, 29-3-24, pp. 513, 545; and *Mineral Industry* for 1921 and 1922.

[2] The crossing of the curves for pig-iron and steel in 1914 is not an error, but is due to the increasing quantity of steel scrap that is used in the manufacture of steel. The curves indicate that some decades were required for the accumulation in the world of a sufficient capital stock of steel for the wastage therefrom, when returned to the smelters, to produce the effect shown. The curves were due to cross in any case in 1914, but the war with its accompanying greatly increased wastage has accentuated the difference. The curves indicate also that the extra wastage of metals due to war is not as great as at first seems to be the case, owing to the ability of modern industry to utilise scrap metal.

activity of the iron and steel industry. In the previous review it was pointed out that the maxima of manganese-ore production coincide with maxima of steel production, whilst the minima lag one year behind. This lag means, of course, overproduction during years of lessened demand, with resultant accumulation of stocks. The rule was not, however, followed in 1919, for difficulty in securing sufficient ocean shipping caused the minimum of production of manganese-ore to precede in 1918 the minimum of production of steel of 1919.

The varying demands of the steel trade make their effect felt on the manganese industry in part through corresponding variations in the price of manganese-ore, and it is interesting therefore to compare the curves of the world's production of iron and steel forming the lower part of figure 12 with the curves showing the price of manganese-ore forming the upper part of the same figure. The two sets of curves have a tendency to move in close sympathy, but the very sharp rise in the curve of prices since 1914 and the sudden fall in 1921-22 indicates the introduction of another factor into the problem besides the activity of the steel trade. This factor is, of course, the excessively high freights that prevailed during the war and for two years after on account of the shortage of shipping. The consequence is that the rapid rise in the curve of market price of manganese-ore cannot be taken as the measure of a corresponding increase in the profits accruing to the manganese industry of India. The sharp rise in 1923 is, however, practically independent of freight charges.

Prices.

In Table 52 is given a statement of the prices of first-grade manganese-ore c.i.f. United Kingdom ports during the quinquennium. The quotations have been taken from the *Mining Magazine*. The mean prices shown in the third column have been obtained by averaging the quotations for the twelve months of each year. In figure 12 these prices are compared with the world's production of pig-iron and steel.[1]

[1] Strictly speaking the portion of the above curves representing the war period should give the world's production exclusive of those countries—Austria, Hungary, Belgium, Germany, and Russia—that were isolated from the world's markets. Such reduced figures give curves very similar to those actually shown, but faulted for the period 1914 to 1918 to a position about 20 million tons lower in the diagram.

TABLE 52.—*Variation in the Price of First-grade Manganese-ore c.i.f. at United Kingdom Ports.*

Date.	Price per unit in pence.	Mean price for year in pence.
January 1919	42 —43	29 6
July 1919	27	
January 1920	36	45 5
July 1920	51	
January 1921	30	17·6
July 1921	14½	
January 1922	13½—13¾	13·9
July 1922	14 —14¼	
January 1923	15½	21 2
July 1923	23	
January 1924	22 —23	22·9
July 1924	23	
January 1925	21½—22	..

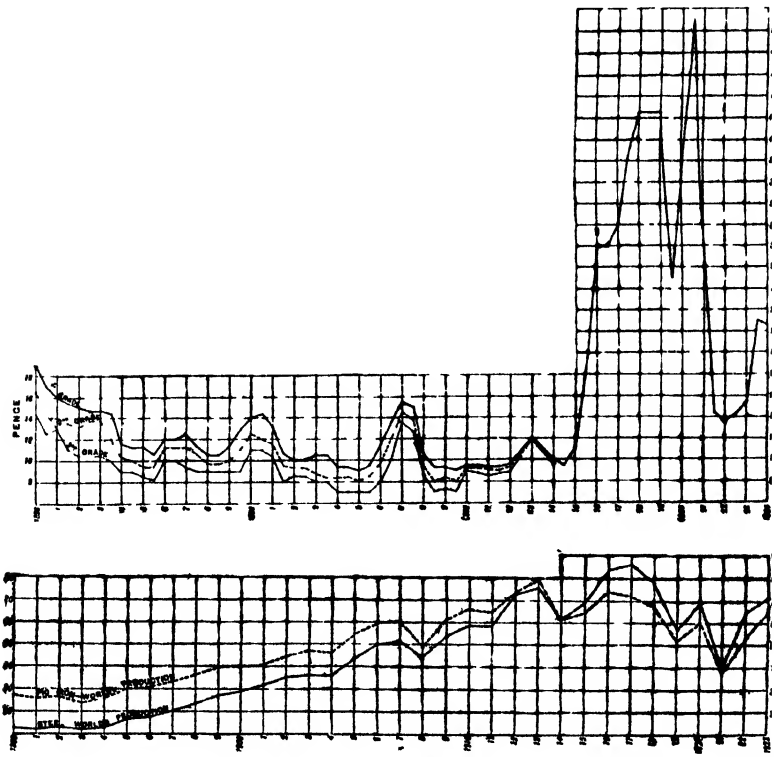

FIG. 12—*Variation in the Prices of Manganese-ore at United Kingdom Ports since 1890, compared with the World's Production of Pig-iron and Steel.*

As already noticed the steep rise in the curve of prices during 1915 to 1917 and the sharp fall in 1920 and 1921 is largely due to enhanced freights during the war period: consequently, in order to discover the extent to which the Indian manganese industry may have benefited by the increased prices it is necessary to eliminate the portions representing freight and reduce to f.o.b. prices. This is desirable also, because, for the same reason, it was found necessary during the war to base the sliding scale of royalties applied in the Central Provinces and Bombay on f.o.b. prices instead of the c.i.f. prices formerly used. The following table gives the necessary data and reveals that although the price of manganese-ore during the war c.i.f. at United Kingdom ports increased by some 100 to 320 per cent., the effective increase to the manganese industry of India was only some 60 to 100 per cent.

Subsequent to the war, however, prices rose in 1920 to a still higher level than at any time during the war in spite of a considerable fall in ocean freights. The result was that exports of manganese-ore during 1920-1921 amounted to more than double the tonnage exported during 1919-20, yielding a very substantial profit to the Indian manganese industry, in spite of the high rupee-sterling exchange rates prevailing in 1920.

TABLE 53.—*Comparison of Ocean Freights with c.i.f. and f.o.b. Prices of Indian Manganese-ore.*

—	Average freights per ton from Calcutta and Bombay to U.K. ports.	Average price of 1st grade ore per unit c.i.f. U.K. ports	Value per ton 50% ore c.i.f. U.K. ports.	Value per ton f.o.b Indian ports.[1]	Corresponding price per unit f.o.b. Indian ports.
	£ s. d.	Pence.	£ s. d.	£ s. d.	Pence.
1914	0 17 9	10·17	2 2 4½	1 3 11½	5·75
1915	2 1 6	20·17	4 4 0½	2 0 0½	9·6
1916	4 1 8	30·7	6 7 11	2 3 9	10·5
1917	5 11 8	37·7	7 17 1	2 2 11	10·3
1918	6 3 0½	42·5	8 17 1	2 11 6½	12·37
1919	3 11 0	29·6	6 3 4	2 9 10	11·96
1920	4 9 4	45·5	9 9 7	4 17 9	23·46
1921	1 5 0	17·6	3 13 4	2 5 10	11·00
1922	0 19 2	13·9	2 17 11	1 16 3	8·70
1923	1 1 4	21·2	4 8 4	3 4 6	15·48

[1] Obtained by deducting from c.i.f. values not only ocean freights, but also destination charges taken at 2*s.* 6*d.* per ton.

During the period now under review the following limited companies were at work. Most of them were formed during the years 1905 to 1907; but the Vizianagram Mining Co. was floated in 1895:—

Companies working.

Bombay—

1. The Shivrajpur Syndicate.
2. The Bamankua Manganese Company.

Central Provinces—

1. The Central India Mining Company.
2. The Indian Manganese Company.
3. The Central Provinces Manganese Ore Company (name changed from Central Provinces Prospecting Syndicate in 1924).
4. The Netra Manganese Company.

Madras—

1. Vizianagram Mining Company.
2. The General Sandur Mining Company.

Mysore—

1. The United Steel Companies (formerly the Workington Iron and Steel Company).

Other prominent workers during this quinquennium have been:—

The Carnegie Steel Company: Central Provinces.

The Tata Iron and Steel Company: Central Provinces.

B. P. Byramjee & Company: Central Provinces.

D. Laxminarayan: Central Provinces.

Nagpur Manganese Mining Syndicate: Central Provinces.

Rai Bahadur Bansilal Abirchand Mining Syndicate: Central Provinces.

The New Gangpur Mining Syndicate: Bihar and Orissa.

Production.

Table 54 shows the production from each district, state and province during the past five years, and fig. 5 on page 18 shows the progress of the industry since its beginning. From this it will be seen that the Central Provinces is by far the most important province as a producer of manganese. The figures in this table represent, except in a few cases, quantities of ore won or raised, and not of ore railed.

TABLE 54.—*Production of Manganese-ore in*

	BIHAR AND ORISSA.				BOMBAY.			CENTRAL PROVINCES.					
—	Gang-pur.	Keon-jhar.	Singh-bhum.	Total.	Chhota Udepur.	Panch Mahals.	Total.	Bala-ghat.	Bhan-dara.	Chhind-wara.	Jubbul-pore.	Nagpur.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1919 .	21,208	..	325	21,533	14,993	29,540	44,533	238,681	34,632	55,310	..	115,852	444,475
1920 .	21,161	..	500	21,661	29,230	34,166	63,396	257,857	90,949	51,517	..	221,912	622,235
1921 .	19,823	..	425	20,248	29,467	44,276*	73,743	253,509	69,291	43,661	..	186,491	553,042
1922 .	16,372	..	..	16,372	17,193	39,703	56,896	169,182	41,143	33,473	..	132,152	375,950
1923 .	20,439	1,968	46	22,453	12,553	35,354	47,907	224,746	79,949	30,066	55	196,403	531,309
TOTAL .	99,003	1,968	1,296	102,267	103,436	183,039	286,475	1,144,065	315,964	214,027	55	852,900	2,527,011
Provincial average	..	..	..	*20,453*	..	..	*57,295*	..	..	..	..	..	*505,402*
Provincial average 1914—18	..	..	..	7,582	..	..	35,043	..	..	..	..	..	405,880

(*a*) Includes the average production

India during the five years 1919 to 1923.

Madras.				Mysore.					Totals for whole of India.	
Bellary.	Sandur.	Vizagapatam.	**Total.**	Chitaldrug.	Mysore.	Shimoga.	Tumkur.	**Total.**		
Tons.	Tons.	Tons.	**Tons.**	Tons.	Tons.	Tons.	Tons.	**Tons.**	**Statute Tons.**	***Metric Tons.***
..	..	2,778	**2,778**	..	..	23,519	1,157	**24,676**	**537,995**	***546,603***
..	..	7,386	**7,386**	..	..	21,667	94	**21,761**	**736,439**	***748,22[illegible]***
..	567	16,593	**17,160**	1,000	..	13,493	600	**15,093**	**679,286**	***690,155***
..	1,470	7,845	**9,315**	1,725	..	14,018	125	**15,868**	**474,401**	***481,991***
2,420	37,318	22,524	**62,271**	1,225	1,200	28,377	313	**31,115**	**695,055**	***706,176***
2,420	39,355	57,126	**98,910**	3,950	1,200	101,074	2,289	**108,513**	**3,123,176**	***3,173,117***
..	..	..	*19,782*	..	..	..	..	*21,703*	*624,635*	*634,629*
..	..	..	13,395	.	..	..	..	24,205	577,457(*a*)	586,696

of 1,402 tons in Central India.

Comparing this quinquennium with the previous five years, it will be seen that the average annual production of manganese-ore for the whole of India shows a moderate increase from 577,457 to 624,635 tons, which, however, is still less than the quinquennial average for the period 1909-1913. The increase recorded was shared by all the provinces except Mysore, for which there was a small decrease, and Central India, which was not a producer; whether absolutely, or calculated on a percentage basis, Bihar and Orissa and Bombay showed the greatest increases. The previous review recorded a falling off in the production of the Madras Presidency from a total of 60,018 tons in 1914 to only 2,230 tons in 1918. During the present quinquennium work was resumed in Sandur in 1921 and became more active in Vizagapatam, with the result that the output for this province expanded from 2,778 tons in 1919 to 62,271 tons in 1923. The total increase for Bombay was largely due to the active exploitation of the Pani mine in Chhota Udepur State, the total output from which rose from 23,305 tons during the previsus quinquennium to 103,436 tons during the quinquennium under review. The increase in Bihar and Orissa was due chiefly to the resumption of work in Gangpur after the solution of the difficulties that followed the death of the former concessionnaire, Babu Madhu Lal Doogar. But there was also a small output from Keonjhar state in Orissa in 1923. In the Central Provinces there was an adjustment of boundaries between the Bhandara and Balaghat districts in 1917, with the result that from that year the output of several deposits[1] formerly credited to Bhandara is now included in the Balaghat total. Owing to an increased output from some of the remaining Bhandara deposits and a decreased output from some of the Balaghat deposits, the adjustment has not produced any noteworthy effect upon the quinquennial totals of the two districts. The Chhindwara district, however, shows a considerable falling off, more than counterbalanced by the increase in the output of the Nagpur district.

Production of foreign countries.

The activity of the Indian manganese industry during the past ten years, and its importance as compared with that of other countries can be seen from Table 55, giving the world's production of manganese-ore for the years 1913

[1] Namely those north of the Bhawanthari river: deposits numbered 1 to 9 in *Mem. Geol. Surv. Ind.*, XXXVII, p. 735, of which Miragpur, Sukli, and Kosumbah, are the most important (see table 73).

to 1922 and for 1923 as far as available. The figures have been taken chiefly from the reports of the Imperial Mineral Resources Bureau and are now given in long tons instead of in metric tons as in the previous reviews.

From this table it will be seen that for some years the three leading countries producing manganese-ore have been Brazil, India and Russia. During the pre-war quinquennium, the output, or rather exports, of Brazil sank from a maximum of 249,941 long tons in 1910 to 120,335 tons in 1913, the average annual exports being 186,172 tons. During the same period, the production of India fluctuated between about 650,000 and 830,000 tons, averaging 712,797 long tons, whilst that of Russia rose almost continuously from 565,856 long tons in 1909 to 1,234,900 tons in 1913, with an annual average of 740,906 tons.

During the war quinquennium, the output, or rather exports of Brazil rose from a minimum of 180,679 tons in 1914 to 524,291 tons in 1918, the average annual exports being 374,222 tons. During the same period, the production of India fluctuated between about 450,000 and 680,000 tons, averaging 577,457 tons, whilst that of Russia, including Georgia, fell continuously from 1,234,900 tons in 1913 and 891,400 tons in 1914 to 150,000 tons in 1918, with an annual average for 1914-1918 of 404,000 tons. During the same period, the production of the United States of America rose from 2,635 tons in 1914 to 305,869 tons in 1918, with an annual average of 95,799 tons. In fact, as is shown graphically in figure 13, the war led ultimately to an almost complete cessation of the Russian manganese industry, to a moderate contraction of that of India, and to the resultant great expansion in the production of manganese-ore in Brazil and the United States of America; so that in 1918 the first three places amongst the world's producers were held by India, Brazil, and the United States of America, in the order named. During the war quinquennium largely increased outputs were forthcoming from some of the other small producers, of which Cuba, Italy, Japan, Spain and Sweden may be mentioned. In addition a multitude of new producers appeared on the scene, of which the Gold Coast and Egypt (Sinai) alone need be mentioned.

TABLE 55.—*World's Annual Production of*

YEAR.	Austria-Hungary. (a)	Brazil. (c)	China (c)	Cuba.	Egypt.	France.	Gold Coast.	India.	Italy.
1913 . .	39,609	120,335	..	11,406	..	7,608	..	815,047	1,596
1914 . .	28,870	180,679	..	9,716	..	6,290	..	682,898	1,622
1915 . .	33,513	284,032	..	9,000	..	10,158	..	450,416	12,375
1916 . .	22,310	495,044	..	33,120	..	10,633	4,258	645,204	17,855
1917 . .	136,884	524,291	..	44,496	..	11,403	31,136	590,813	24,138
1918 . .	177	387,066	20	81,966	27,064	9,712	30,292	517,953	31,383
1919 . .	5,182	202,419	2,997	(c)31,212	47,965	6,903	35,189	537,995	30,345
1920 . .	37,161	446,445	24,923	(c)22,163	76,316	10,200	40,970	736,439	35,577
1921 . .	56,866	271,263	25,223	(c)622	54,180	1,892	7,195	679,286	5,025
1922 . .	43,907	335,230	18,926	(c)9,059	102,469	689	66,113	474,401	4,619
1923 . .	70,086	232,041	27,234	19,320	130,256	330	139,634	695,055	9,451

(a) Figures for 1913 to 1915 include Bosnia and Herzegovina: for 1916 Bosnia and Herzegovina only: for 1917 exclude Austria: for 1918, 1919, are for Austria only: for 1920, Austria and Czechoslovakia: for 1921, 1922 and 1923, are for Austria, Czechoslovakia, and Jugoslavia.

(b) Figures not available.

(c) Exports.

Manganese-ore during the years 1913 to 1923.

(Statute Tons.)

Japan.	Russia and Georgia.	Spain.	Sweden.	United Kingdom.	United States.	Other countries.	World's Total.	*Percentage of total produced in India.*
17,755	1,234,900	21,247	3,937	5,393	4,048	1,322	**2,284,203**	*35·7*
16,803	891,400	12,944	3,584	3,437	2,635	601	**1,841,479**	*37·1*
25,470	528,900	14,098	7,485	4,640	9,613	3,779	**1,393,479**	*32·3*
48,547	(*e*)247,000	13,950	8,751	5,140	31,474	29,764	**1,613,050**	*40·0*
50,579	(*e*)201,380	56,550	19,554	9,942	129,405	32,978	**1,863,549**	*31·7*
56,109	(*e*)150,000	76,465	16,304	17,456	305,869	43,862	**1,751,698**	*29·6*
22,523	56,200	65,614	12,081	12,078	55,322	41,528	**1,163,553**	*46·2*
5,389	95,463	20,914	14,686	12,875	94,420	48,127	**1,722,068**	*42·8*
3,821	(*c*) 28,364	19,775	6,145	514	13,531	(*d*) 26,298	**1,200,000**	*56·6*
4,371	(*c*) 192,651	25,046	4,438	250	13,404	(*d*) 14,427	**1,310,000**	*36·2*
4,926	(*c*)407,401	28,635	(*b*)	2,021	31,500	(*d*) 32,110	**1,830,000**	*38·0*

(*d*) Estimated.
(*e*) Georgia only.

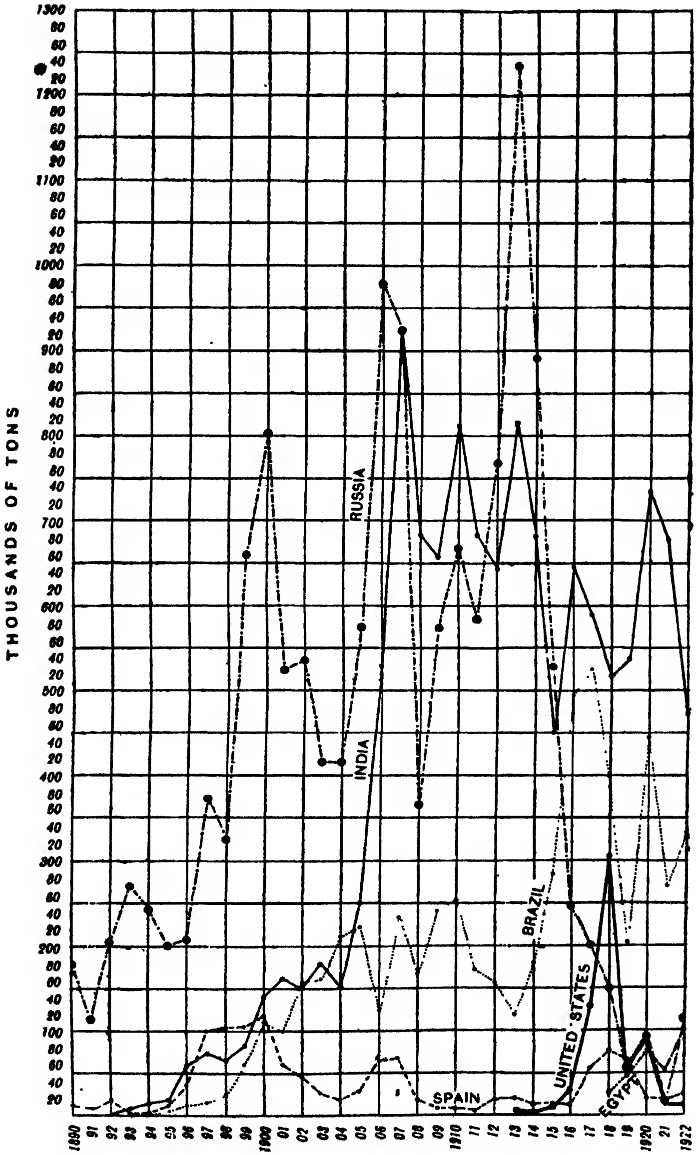

Fig. 13.—*Production of manganese-ore in the six leading countries.*

During the quinquennium under review, the Indian production has recovered to an average of 624,635 tons, the Brazilian exports have fallen somewhat to an average of 313,839 tons (1919-1923) and may show a further fall in the future on account of inadequate railway facilities, whilst the Russian exports have averaged some 170,000 tons, probably largely from stocks. During the quinquennium, the output of the United States of America has reverted nearly to pre-war levels, as has that of many other countries, but the production of Egypt rose to 130,291 tons in 1923 and that of the Gold Coast to 139,634 tons in the same year, these two countries then ranking as the 5th and 4th producers respectively. China has now also become a small regular producer. The Egyptian deposits are in Sinai only 10 to 15 miles from the port of Abu Zenima, and the total ore reserves are estimated at 11,848,000 tons, averaging 32·3 per cent. manganese and 25 per cent. iron, the ore being a ferruginous manganese-ore. The ore from the Gold Coast is, however, in part first-grade manganese-ore, the ore as shipped showing 51 to 52 per cent. manganese. As the proposed rate of shipping from Sinai is 300,000 tons annually, whilst the output from the Gold Coast during 1924 is reported to have exceeded the figure given above, it seems probable that the next quinquennium will show a considerable increase in the production of these two countries. The ore from the Gold Coast is more likely to compete with the Indian ore than that of Sinai.

In spite, however, of the appearance of these new producers, India has maintained her position. During the pre-war quinquennium, India produced 40·8 per cent. of the world's average total annual production of some 1,750,000 tons of manganese-ore; during the war quinquennium, the Indian proportion fell to 34·1 per cent. out of an average total annual production of some 1,690,000 tons, whilst, during the post-war quinquennium, the Indian proportion has risen to 43·2 per cent. of the reduced world's output of some 1,445,000 tons annually.

In previous reviews a table has been given of the world's production of manganiferous iron-ores. Data are, however, so scanty that in table 56 of the present review are given the figures for the United States only. Formerly, all manganiferous ores containing less than 40 per cent. manganese were included, but, since 1918, the line between manganese-ores and manganiferous

Production of manganiferous iron-ores.

iron-ores has been drawn at 35 per cent. manganese.[1] The importance of large stores of manganiferous iron-ores to a country poor in manganese-ores proper is shown by the case of the United States, where an insufficiency of imports of manganese-ore during the war was mitigated by a large expansion in the output of indigenous manganiferous iron-ores accompanied by modifications in furnace practice where necessary. In the case of Germany, also, the cessation of imports of manganese-ore from Russia and India was met to a large extent by a greatly increased production of the manganiferous iron-ores of Siegerland,[2] and it is unfortunate, therefore, that the relevant figures are not available for inclusion in the above table. In addition to the United States of America, there is a small production of manganiferous iron-ore in Spain, Algeria, Greece and Italy; further, by the United States of America standards the Egyptian ore (see Table 55) would be classified as manganiferous iron-ore, as also would a very small proportion of the Indian ore.

TABLE 56.—*United States Production of Manganiferous Iron-ores from 1918 to 1923.*

(Long Tons.)

Year.	Ore containing from 10 to 35 per cent Mn.	Ores containing from 5 to 10 per cent Mn.	Total.
1918	916,163	254,299	1,170,462
1919	211,632	112,303	323,935
1920	357,279	279,687	636,966
1921	8,439	62,670	71,109
1922	344,674	251,614	596,288
1923	319,666	1,072,457	1,392,123

[1] See p. 218 for a scheme of classification of manganese-ores.
[2] H. C. H. Carpenter, *Nature*, 4-11-15, (p. 257).

For comparison with the annual figures of production of manganese-ore in India, the export figures during the years 1919-20 to 1923-24 are given in (Table 57 stated separately for each port.)

Exports.

TABLE 57.—*Exports of Indian Manganese-ore from 1919-20 to 1923-24.*

(Statute Tons.)

Year.	Vizagapatam.	Bombay.	Calcutta.	Mormugao (*a*)	Yearly Total.
1919-20 . .	4,555	249,667	127,894	..	382,116
1920-21 . .	12,610	391,650	375,582	25,997	805,839
1921-22 . .	6,332	279,084	234,081	10,874	530,371
1922-23 . .	17,060	406,832	365,385	87,917	877,194
1923-24 . .	10,875	347,723	381,290	74,454	814,342

(*a*) Figures relate to calendar years and exclude ore raised in Goa, of which 1,542 tons were exported in 1922.

From Table 58, giving the total Indian production and exports for the years 1892 to 1923, it will be seen that by the end of 1923 there was an excess of production over exports of nearly 580,000 tons, of which, however, 228,850 tons is accounted for by railings to Tatanagar, Kulti, and Burnpur, from 1914 to date (from 1911 for Tatanagar) after allowing for ore sold by the Tata Iron and Steel Co. for export; the remainder represents stocks accumulated at the mines and ports and is smaller by about 400,000 tons than the surplus recorded in the previous review after allowing for ore railed to the iron works. This reduction of stocks is due to the very large exports during the years 1920-21, 1922-23 and 1923-24, in each of which the exports exceeded 800,000 tons, a figure that had only once previously been reached (804,796 tons in 1913-14).

TABLE 58.—*Comparison of Indian Manganese-ore Production with Exports.*

(Statute Tons.)

Period.	Ore produced.	Ore exported.	Excess of production over exports.
1892 to 1903	929,145	..	..
1892-93 to 1903-04	..	916,386	12,759
1904 to 1908	2,545,718	..	..
1904-05 to 1908-09	..	2,217,596	328,122
1909 to 1913	3,563,984	..	..
1909-10 to 1913-14	..	3,471,416	92,568
1914 to 1918	2,887,284	..	..
1914-15 to 1918-19	..	2,457,790	429,494
1919 to 1923	3,123,176	..	..
1919-20 to 1923-24	..	3,409,862	*—286,686*
TOTAL	13,049,307	12,473,050	576,257

Distribution of Indian manganese-ore exports.

The distribution amongst foreign countries of the manganese-ores exported from India during the quinquennium is shown in Table 59. The figures for the previous period, the war quinquennium, as compared with the similar data for the pre-war quinquennium showed certain abnormal features. The first feature was the disappearance of Belgium, Germany, Holland, and Austria-Hungary, from the importing countries for the period of the war: the second was the large decrease in the exports to France and the United States: and the third the large increase in the exports to the United Kingdom—1,680,796 tons in the war quinquennium as compared with 966,111 tons during the previous period. During the quinquennium now under review the data showed a partial reversion to the pre-war figures. The total imports of Germany, Holland and Belgium (most of which are for consumption in Germany) were 1,051,841 tons against 876,536 tons in the pre-war periods. The imports of France rose to 531,728 tons against 484,596 tons for the pre-war period; those of the United States of America rose to 327,529 tons against 660,988 tons for the pre-war period, whilst those of the United Kingdom fell to 1,224,288 tons against 966,111 tons of the pre-war period. The net balance was a total of exports from India of 3,210,620 tons during the post-war quinquennium against 3,035,530 tons during the pre-war quinquennium.

TABLE 59.—*Distribution of exported Indian Manganese-ore for the years 1919-20 to 1923-24* (a).

(Statute Tons.)

Year.	Austria-Hungary.	Belgium.	Egypt.	France.	Germany.	Italy.	Japan.	Netherlands.	Sweden.	Switzerland.	United Kingdom.	United States.	Other countries.	Total recorded export for the year.
1919-20 .	..	104,829	..	48,000	..	8,750	300	1,350	..	..	199,584	19,300	3	382,116
1920-21 .	..	170,564	..	81,016	1,500	13,700	500	8,000	2,800	500	330,801	170,460	1	779,842
1921-22 .	..	259,902	..	94,205	16,517	9,200	1,752	35,200	..	..	74,939	27,782	..	519,497
1922-23 .	..	280,156	..	144,375	..	15,893	5,568	19,100	..	..	311,043	13,142	..	789,277
1923-24 .	..	133,523	750	164,132	9,000	14,079	1,438	12,200	..	..	307,921	96,845	..	739,838
Totals (1919-20 to 1923-24).	..	**948,974**	**750**	**531,728**	**27,017**	**61,622**	**9,558**	**75,850**	**2,800**	**500**	**1,224,288**	**327,529**	**4**	**3,210,620**
Totals (1913-14 to 1918-19).	**4,030**	**72,603**	**200**	**233,721**	**14,250**	**61,025**	**62,536**	..	..	..	**1,680,796**	**239,616**	..	**2,368,778**
Totals (1908-09 to 1912-13).	**13,610**	**794,859**	.	**484,596**	**33,402**	**14,400**	**19,289**	**93,275**	..	..	**966,111**	**660,968**	--	**3,035,530**

(*a*) Excludes exports *viâ* Mormugao.

In Vizagapatam and Mysore an adequate supply of labour seems to be easily obtainable, but in the Central Provinces, Central India, the Sandur Hills, and other parts, labour has frequently to be imported. To relieve themselves of unnecessary trouble and responsibility the mine managers find it preferable to work through contractors, paying them at a given rate per 1,000 cubic feet of stacked and cleaned ore, and for dead-work at a given rate per 1,000 cubic feet of cavity made in the quarry in the case of soft 'deads,' or per 1,000 cubic feet of waste measured in tubs or stacked in the case of hard 'deads.' The daily rates paid to the coolies by the contractors for an eight hours' day vary between the following limits in different parts of India[1] :—

Labour.

	Annas.
Men	4 to 8
Women	2 to 5
Children (over thirteen)	2 to 4

But in the Central Provinces most coolies work on a piece work system at rates based on the above maximum daily rates, and in consequence often earn less than the full rates because they do not work full time; some men, however, earn sums considerably in excess of the above.

The average daily number of workers during the past five years is shown in Table 60, the average annual figure being somewhat higher than in any previous quinquennium.

In order to permit of the comparison of the manganese with the coal industry as regards labour, the figures appertaining only to those mines that come under the Mines Act, 1901, are given in Table 61. From these figures it is seen that the average number of persons employed daily on the manganese mines under the Act has been 14,134 for an average annual output of 495,255 tons compared with 13,242 persons and an average annual output of 482,857 tons of ore for the previous quinquennial period. The number of tons of ore won annually per person employed has decreased steadily from 39·4 tons during the pre-war quinquennium to 36·6 tons during the war quinquennium and 35·0 during the period now under review. This decrease is due to the fact that much of the easily-won ore has been extracted so that more dead work is necessary every year. The output of coal per person employed was nearly three times the above figure. The death rate has been

[1] The lower rates refer to cultivators in Madras who combine mining with agriculture.

0·40 per 1,000 persons employed, as compared with 1·36 in the case of coal: these figures are higher than for the period 1914-18, when the corresponding figures were 0·18 and 1·14 respectively. At the same time the number of deaths per million tons won has increased in the case of manganese from 6 in 1914-18 to 11·3 in 1919-23, and in the case of coal from 10·7 to 13·9.

TABLE 60.—*Daily Number of Workers employed at the Manganese Quarries from 1919 to 1923.*

YEAR.	Bihar and Orissa.	Bombay.	Central Provinces.	Madras.	Mysore.	TOTAL.
1919 . .	1,224	1,670	13,937	257	323	**17,411**
1920 . .	1,090	2,369	16,404	588	249	**20,700**
1921 . .	1,149	2,936	19,522	1,290	356	**25,253**
1922 . .	1,058	2,341	12,388	668	343	**16,798**
1923 . .	1,430	1,966	16,675	2,742	829	**23,642**
Average .	*1,190*	*2,256*	*15,785*	*1,109*	*420*	*20,760*

TABLE 61.—*Labour Statistics for Manganese Mines under the Mines Act, 1901.*

Year.	Average number of persons employed daily.	Production.	Output per person.	Number of deaths.
		Tons.	Tons.	
1919 . . .	12,423	420,184	33·8	12
1920 . . .	13,264	582,636	43·9	3
1921 . . .	17,327	534,757	30·9	4
1922 . . .	12,025	392,322	32·6	5
1923 . . .	15,629	546,378	34·9	4
TOTAL .	**70,668**	**2,476,277**	..	**28**
Average .	*14,134*	*495,255*	*35·0*	*5·6*

The chief items in the cost of placing manganese-ore on the markets in Europe and America are the following :—

Cost of mining and transport.

(1) Cost of mining (labour, tools, plant, establishment).
(2) Cost of transport to the railway.
(3) Cost of transport to the port of shipment.
(4) Cost of handling at the port of shipment.
(5) Cost of shipping to Europe or America.
(6) Destination charges.

Each of these six items—the first five of which vary according to the situation of the deposit—has been considered in detail in *Memoirs, Geol. Sur. Ind.*, XXXVII, Chapter XXIII, to which the reader is referred. In an earlier review an abstract was given showing the average cost of delivering *c.i.f.* at English and Continental ports ore derived from several of the producing areas. These figures were in the main based on information collected prior to 1910 and with the general rise in prices due to the war have ceased to be applicable. Revised figures for all the areas concerned have not been obtained, but it will be sufficient to give as an example the following revised figures for the Central Provinces, the most important producing province.

—	*Viâ* Bombay.			*Viâ* Calcutta.		
	Limits.		Average.	Limits.		Average.
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Cost of mining (labour, tools, plant and administration).	2 12 0	12 0 0	6 8 0	..	..	6 8 0
Transport to rail-head . .	0 3 0	5 10 0	1 8 0	..	..	1 8 0
Railway freight . . .	11 1 3	14 6 0	12 4 0	11 10 0	14 0 0	12 4 0
Handling at port . . .	3 1 0	3 8 0	3 4 0	2 0 0	2 4 0	2 2 0
Agents' commission and administration.	0 2 0	1 10 0	0 12 0	0 2 0	1 10 0	0 12 0
			24 4 0			23 2 0

These figures are applicable to the period 1919 to 1923, and on comparing them with the figures given in the memoir referred to above and in the previous review, it will be seen that the average cost of delivering ore from the Central Provinces *f.o.b.* Bombay increased from

about Rs. 14 per ton in the pre-war quinquennial period and about Rs. 17 during the war quinquennium to about Rs. 24 during the post-war quinquennium. These increases are due to increases under every item in the total, and in effect, taking an exchange value for the rupee of 1*s*. 4*d*., it will be seen that the cost of delivering manganese-ore *f.o.b.* Bombay has increased by about 70 per cent., as compared with pre-war costs. A comparison of the figures given in Table 53 with the average price of first-grade manganese ore per unit during the pre-war quinquennium *f.o.b.* Indian ports (6·18*d.*) will show that the increased market price of manganese-ore has met adequately the increased costs of production.

Royalties.

In British India the royalty leviable on the base metals is—

'2½ per cent. on the sale value at the pit's mouth, or on the surface, of the dressed ore or metal, convertible at the option of the Local Government to an equivalent charge per ton to be fixed annually for a term.'

On account of the inconvenience and labour involved in assessing rates of royalty separately for each manganese-ore deposit and producer, it has for some years been customary in each area to assume average figures for the composition of the ore and for the costs of mining, transport, etc., and to apply them without distinction to all cases. The first sliding scale drawn up on these assumptions was framed by the Central Provinces administration and was based on c.i.f. values at United Kingdom ports: during the war period the high ocean freights upset the schedule and it was replaced by the following sliding scale based on f.o.b. values Bombay :—

TABLE 62.—*Royalties, in annas per ton, leviable on Manganese-ore extracted in the Central Provinces and Bombay.*

F.o.b. price per unit of first-grade ore.	Royalty leviable per ton of ore.
Pence.	*Annas.*
5½	½
6	1⅕
6½	1⅘
7	2⅖
7½	3
8	3⅗
8½	4⅕
9	4⅘
9½	5⅖
10	6

The wide fluctuations in the rupee-sterling exchange during the post-war period rendered this schedule also inapplicable: it would have been easy to rectify this difficulty by basing royalties on the f.o.b. price stated in annas instead of pence, but on account of the possibility of variation of other factors, the Local Government decided in 1921 to abandon sliding scales altogether and to revert to the system of assessing royalty at 2½ per cent. on the sale value of the ore at the pit's mouth. This necessitates detailed returns by each producer based on the actual facts of each year and forms suitable for the purpose have been drawn up. The actual rates of royalty charged during the quinquennium in the Central Provinces are shown in Table 63. Bombay has adopted the same method of assessment. The f.o.b. prices are added to permit of comparison of the results yielded by the two methods.

TABLE 63.—*Royalties actually levied in the Central Provinces during the years 1919 to 1923.*

Year.	Royalties levied.		Average f.o.b. price for year
	January to June.	July to December.	
	Annas.	*Annas.*	*Pence.*
1919	3	3	12·0
1920	3	4·8	23·5
1921	4·8	3·6	11·0
1922	4·2	5·4	8·7
1923	8·2	11·8	15·5

In Bihar and Orissa royalty is levied at 2½ per cent. on pit's mouth value, which has been taken as equivalent to 6 annas a ton during the last few years.

In the Native States a fixed royalty irrespective of price is usually arranged when a prospecting license or mining lease is granted. The rates prevailing in certain States are as follows:—

TABLE 64.—*Royalty, in annas per ton, levied in certain Native States and Zamindari lands.*

State.	Royalty.
Jhabua State, Central India	4 annas.
Mysore State	5 per cent. on the pit's mouth value of the ore subject to a minimum of 10 annas a ton. (*a*)
Sandur State, Madras	6 annas.
The Vizianagram Samasthanum, Madras .	4 „

(*a*) Ores containing not more than 44 per cent. of manganese are subject to a minimum royalty of only 6 annas

Valuation of manganese-ore.

From table 52 and the diagram (fig. 12) on page 191, it will be seen that the price per unit of manganese, and consequently the price per ton of manganese-ore obtained on its delivery *c.i.f.* at the port of destination, is subject to great variations. Up till November 1909 (*Mining Journal*) the following classification was in use :—

1st grade	50 per cent. Mn. and upwards
2nd ,, ...	47—50 per cent. Mn.
3rd ,, ...	40—47 per cent. Mn.

But from December 1909 the following schedule was employed :—

1st grade	50 per cent. Mn.
2nd ,, ...	48—50 per cent. Mn
3rd ,, ...	45—48 per cent. Mn.

and during the war quotations have been given for first-grade ore only. Since the war, also, quotations have been practically confined to first-grade ore; but of late quotations for second-grade ore have appeared at intervals, and have been usually about one or two pence below first-grade prices. The lower limit for first-grade ore has fallen to 48 per cent. Mn.

As an example of the way in which the schedule of prices was applied we can take the case of a 50 per cent. ore from the Central Provinces in December 1914. The average price at this time was 11 pence per unit. The price then paid per ton for this ore would be 50×11 pence=£2—5—10.

The prices given in table 52, apply to ore delivered in the United Kingdom; and for this scale to be applicable it was formerly necessary that the ore should not contain more than 10 per cent. of silica and 0·10 per cent. of phosphorus.

In the United States, before the war, a schedule of prices was fixed periodically by the Carnegie Steel Company and one such schedule is quoted in a previous Quinquennial Review. The great rise in prices during the present period led to the announcement in 1918 by the War Industries Board of a revised schedule fixing the price per unit of manganese for each 1 per cent. rise from 35 per cent. upwards. The following is an abstract :—

	Per unit.
35 per cent. Mn.	\$ 0·86
40 ,, ...	\$ 1·02
45 ,, ...	\$ 1·12
50 ,, ...	\$ 1·22
54 ,, and upwards	\$ 1·30

The above prices were based on ore containing not more than 8 per cent. silica or 0·25 per cent. phosphorus and are subject to premia and penalties for amounts of silica respectively below and above the standard figure, and to penalties for amounts of phosphorus above the standard, no premium being offered for phosphorus below the standard. This illustrates the point referred to in the previous review that silica appears to be of much greater importance as a deleterious constituent than phosphorus. For details of these premia and penalties reference should be made to page 463 of "*The Mineral Industry*" for 1918.

The schedule given above can no longer apply, but no later figures ave been discovered.

The prices noticed above are those relating to manganese-ores intended for use in the iron and steel industry. For ores suited for use in the chemical industries as oxidising agents much higher prices are often obtained. For chemical purposes it is not the percentage of manganese that is of importance, but the percentage of oxygen liberated on treating the ore with acid, *i.e.*, the *available oxygen*. This is usually expressed in terms of the percentage of manganese peroxide, MnO_2. Not only does the percentage of MnO_2 affect the price, but also the ease with which the oxygen is liberated. Further, impurities that are soluble in acid, and so cause an unnecessary consumption of it, are deleterious. The best minerals for these purposes are pyrolusite, psilomelane, and hollandite. For the glass industry the ore must be as free as possible from iron. The only Indian pyrolusite yet found sufficiently pure for the glass industry is that of Pali in the Nagpur district. A picked specimen of this giving 95·57 per cent. MnO_2 showed only 0·06 per cent. Fe_2O_3.

Valuation for chemical purposes.

It is customary to divide the ores of iron and manganese into iron-ores, manganiferous iron-ores, and manganese-ores. The least percentage of manganese in an iron-ore that is usually paid for is said to be 5 per cent. and with less than 5 per cent. of manganese it hardly seems necessary to prefix the adjective 'manganiferous.' The dividing line between manganiferous iron-ores and manganese-ores was formerly taken at 44 per cent. manganese (=70 per cent. MnO_2). Later, ores with as little as 40 per cent. manganese have been termed manganese-ores, and those below this limit mangani-

Nomenclature of manganese-ores and manganiferous iron-ores.

ferous iron-ores.[1] According to this method one often sees an ore referred to as manganiferous iron-ore that contains much more manganese than iron. Such a difficulty can easily be avoided by creating a class for *ferruginous manganese-ores*. Accordingly, in *Memoirs, Geol. Surv. Ind.*, XXXVII, page 500 (1909), the following classification has been proposed. It is applicable to all ores containing over 50 per cent. of Mn+Fe.

——	Mn. per cent.	Fe per cent.
Manganese-ores	40—63	0—10
Ferruginous manganese-ores . . .	25—50	10—30
Manganiferous iron-ores . . .	5—30	30—65
Iron-ores	0—5	45—70

Analyses of manganese-ores.

On pages 501 to 509 of the work cited above a series of tables of analyses of Indian ores will be found. A good idea of the quality of the ores obtained in different parts of India can be gleaned from the range and mean values of these analyses as summarised in the tables 71 and 72 of the previous review. The second of these only is now repeated (table 65), but in addition a new table (No. 66) is added representing the composition of the manganese-ores worked in India during the quinquennial period under review and based on figures for which I am indebted to the various mining companies. Certain differences between the figures in these two tables merit comment. In the case of the Panch Mahals, the figures given in table 65 relate to outcrop samples taken before the deposits were opened up and without any selection, such as would naturally take place when the ores were worked; the average quality of ore as exported is of much higher grade. The ores from the Central Provinces worked during the present period show a slight decrease in manganese contents, a slight increase in silica contents, and a slight increase of phosphorus contents, compared with the analyses summarised in table 65, which relate chiefly to samples taken by myself in 1903-04. The ores from Sandur State as exported show roughly the same total manganese and iron contents, as in the earlier figures, but the iron contents are markedly higher at the expense of the manganese contents.

[1] In the United States in 1918 the limiting percentage was lowered to 35.

TABLE 65.—*Mean of Analyses of Manganese-ores and Manganiferous Iron-ores from the different Districts and Provinces of India.*

PROVINCE.	BIHAR AND ORISSA.				BOMBAY.				CENTRAL INDIA.	CENTRAL PROVINCES.						
DISTRICT.	GANGPUR.		SINGHBHUM.		BELGAUM.		PANCH MAHALS.	SATARA	JHABUA.	BALAGHAT.	BHANDARA.	CHHINDWARA.	NAGPUR.	JUBBULPORE.		
Class of ore.	Higher grade.	Lower grade.	Manganese-ore.	Manganiferous iron-ore.	Ferruginous manganese-ore.	Manganiferous iron-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganiferous iron-ore.	Iron-ore.
Number of analyses.	Half the limits	Half the limits.	3	3	10	2	4	4	5	13	13	8	30	3	7	4
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Manganese .	49·5	45	47·66	11·84	44·77	10·53	41·68	40·79	46.94	51·88	51·94	52·72	51·53	45·56	20·26	0·96
Iron . .	7	7·5	2·90	34·93	10·33	49·55	4·07	6·94	8·44	7·40	7·27	7·08	6·24 ([illegible])	4·79	28·78	50·50
Silica .	6	8	4·63	16·46	1·40	2·27	19·11	3·75	8·14	3·74	4·59	7·16	7·25	2·68	12·99	10·76
Phosphorus	0·12	0·13	0·34	0·74	0·035	0·023	0·20	0 07	0·20	0·11	0·14	0·14	0 11	0·215	0·25	0·32
Moisture .	..	..	0·63	1·17	..	..	0·35	1 99	0·43	0·37	0·44	0·38	0·49 ([illegible])	0·56	..	0·336
Manganese + iron	56·5	52·5	50·53	46·77	55 10	60·08	45 75	47·73	55 38	59·28	59·21	59 80	57 77	50·35	49·04	51·4

TABLE 65 (contd.).—*Mean of Analyses of Manganese-ores and Manganiferous Iron-ores from the different Districts and Provinces of India.*

PROVINCE.	MADRAS.				MYSORE.		
					SHIMOGA.		
DISTRICT.	SANDUR.	VIZAGAPATAM.			New Mysore Manganese Company.		Shimoga Manganese Company.
			Supplied by Vizianagram Mining Company.				
Class of ore.	Ferruginous manganese-ore.	Ferruginous manganese-ore.	Manganese-ore.	Ferruginous manganese-ore.	Ferruginous manganese-ore. Higher grade.	Ferruginous manganese-ore. Lower grade.	Manganese ore.
Number of analyses.	6	12	8	7	3	Half the limits.	9
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent
Manganese	47 75	42·96	44·34	46 75	46 75	37	49·10
Iron	11·45	11·22	9·08	15·20	10·06	15	7·74
Silica	0·61	4·29	4·15	5·72(?)	1 77	4	2·62
Phosphorus	0·030	0·27	0·32	0 335	0·031	0·035	0·085
Moisture	..	0·90	..	..	0·95	1	..
Manganese + iron	59·20	54·18	53·42	51·95	56·8[illegible]	52	56 84

TABLE 66.—*Composition of Indian Manganese-ores as Exported.*

PROVINCE.	BIHAR AND ORISSA.		BOMBAY.				CENTRAL PROVINCES.		
PRODUCER	NEW GANGPUR MINING SYNDICATE.		SHIVRAJPUR SYNDICATE.				CARNEGIE STEEL COMPANY.	CENTRAL INDIA MINING COMPANY.	
District or State.	*Gangpur.*		*Chhota Udepur.*	*Panch Mahals.* Shivrajpur.		*Panch Mahals.* Bamankua.	*Balaghat.*	*Balaghat, Bhandara and Nagpur.*	
Class of ore.	1st grade.	2nd grade.	—	1st grade.	2nd grade.	1st grade.	1st grade.	1st grade.	2nd grade.
Tonnage represented . .	51,471	44,106	102 062	81,264	49,447	52,325	42,233	185,270	81,287
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Manganese	49·60	45·85	47·60	50·00	46·50	48 25	49·04 —50·69	48·81 —49·62	46·08 —48·06
Iron	7 82	8·29	4·76	5·08	4·44	3·32	5·25 — 6·50	..	..
Silica	4·96	5 04	4·72	5·11	9·60	10·00	5·01 — 7 50	6·02 — 9·15	7·34 —11·37
Phosphorus . . .	0 205	0·144	0 160	0·200	0·187	0·200	0·067— 0·238	0·129— 0·140	0·150— 0·241
Manganese + iron . .	57 42	54 14	52 36	55·08	50·94	51·57	55·54 —51·89	..	..

TABLE 66 (contd.)—*Composition of Indian Manganese-ores as Exported.*

PROVINCE.	CENTRAL PROVINCES—(contd.).					MADRAS.			MYSORE.
PRODUCER.	CENTRAL PROVINCES MANGANESE ORE COMPANY.		INDIAN MANGANESE COMPANY.			GENERAL SANDUR MINING COMPANY.	VIZANAGRAM MINING COMPANY.		UNITED STEEL COMPANIES.
District or State.	*Balaghat. Bhandara and Nagpur.*		*Chhindwara.*		*Nagpur.*	*Sandur.*	*Vizagapatam.*		*Shimoga.*
Class of ore.	1st grade (1919-23).	2nd grade (1922-23).	1st grade.	2nd grade.	1st grade.	Ferruginous manganese-ore.	Ferruginous manganese-ore. Higher grade.	Ferruginous manganese-ore. Lower grade.	Ferruginous manganese-ore.
Tonnage represented . .	Total Shipments	20,906	205 397	7,771	125 068	30,659	..	..	Basis of Shipments.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Manganese	51·00	45·00	52·8 —54·0	46·5 —46·7	48·3 —51·4	39·0	44·6	38·4	40·0
Iron . . .	6·07*	10·86	4·2 — 5·7	6·9 — 8 0	5·4 — 6·0	18·0	9·9	14·2	13·0
Silica	7·42	10·26	7·8 — 9·3	9 0 —11·8	5·7 — 8·6	1·5	4·6	5·7	3·5
Phosphorus	0·107	0·185	0·105— 0·184	02·06 — 0·254	0·172— 0·226	0·025	0·37	0·29	0·055
Manganese and iron .	57·07	55·86	57·0 —58·4	53·4 —54·5	53·3 —57·4	57·0	54·5	52·6	53·0

* Fe not on shipments, but on sales to Tata Iron and Steel Co. during same period.

Analyses of cargoes of Indian and foreign ores landed at Middlesborough.

In order to show the value of the Indian ores relative to those of certain foreign countries two tables (73 and 74) were given in the previous review showing the limits and averages, respectively, of a large number of cargoes of manganese-ores and manganiferous iron-ores landed during the years 1897-1906 at Middlesborough. In the present review only the table of average values is repeated. These figures represent not only Indian manganese-ores, but also the manganese-ores of the Caucasus, Brazil and Chile, and the manganiferous iron-ores of Greece and Spain (*viâ* Carthagena). From these figures it will be seen that the Indian ores contain less moisture than those of the other countries. Some of the latter contain such large quantities of moisture.—Caucasus, 8·67 per cent.; Brazil, 11·35 per cent.; and Spain, 8·44 per cent.—that it is necessary to reduce the analyses to their condition when dried at 100° C. before any fair comparison can be made. This has been done by assuming that the constituents of the ores not given in the 'as received' columns would if determined make the analyses add up exactly to 100. From the figures representing the dried ores it will be seen that the Indian ores stand first as regards manganese contents, with Brazil a close second; as regards silica, Brazil stands first, with India second: as regards phosphorus, however, India stands last but one, the only ores containing more phosphorus being those of Russia: the Indian ores contain much less iron than the manganiferous iron-ores of other countries; but of the true manganese-ores they contain the highest amounts of iron, in spite of the fact that they also contain the highest amounts of manganese. The high iron contents of the Indian ores may be regarded as a point in their favour, or otherwise, according to the use to which the ores are to be applied. It is true that the high iron contents make it more difficult to manufacture the very highest grades of ferro-manganese from the Indian ores; but, on the other hand, if the very highest grades are not required, then the iron is of considerable value. Both manganese and ron are of use in this case, and the buyer obtains the following totals of Mn+Fe when he buys the ores of the different countries:—

	Mn+Fe. Per cent.
India	57·17
Brazil	54·09
Russia	50·41
Chile	48·40
Greece	47·99
Spain	44·27

TABLE 67.—*Means of Analyses of Cargoes of Manganese-ores and Manganiferous Iron-ores landed at Middlesborough during the ten years 1897 to 1906.*

COUNTRY.	INDIA.		RUSSIA. (CAUCASUS).		BRAZIL.		CHILE.		GREECE.			SPAIN (*viâ* CARTHAGENA).	
Class of ore	Manganese-ore.		Manganese-ore.		Manganese-ore.		Manganese-ore.		Manganiferous iron-ores.			Manganiferous iron-ores.	
									Raw.		*Calcined.*		
Number of cargoes	26		77		25		9		54		18	24	
Period	1900—1906		1898—1906		1898—1906		1898—1903		1897—1906		1897—1903.	1897—1905.	
Method of reporting analysis.	As received.	Dried at 100° C.	As received.	Dried at 100° C.	As received.	Dried at 100° C.	As received	Dried at 100° C.	As received.	Dried at 100° C.	Dried at 100° C.	As received.	Dried at 100° C.
Manganese . . .	50·49	50·86	45·28	49·53	44·60	50·314	47·51	47·99	16·15	16·96	43·01	19·35	21·13
Iron	6·26	6·31	0·76	0·83	3·35	3·78	0·41	0·41	29·54	31·03	41·32	21·19	23·14
Silica	5·67	5·71	9·29	10·17	1·81	2·04	7·26	7·33	7·37	7·33	7·33	11·18	12·21
Phosphorus . .	0·126	0·127	0·147	0·161	0·040	0·052	0·015	0·011	0·022	0·023	0·023	0·013	0·014
Moisture . .	0·72	.	8·67	..	11·35	..	1·01	..	4·79	..	..	8·44	..
Alumina, siliceous matter, etc.	0·75	6·80	11·66	12·77	2·73	3·08	12·52	12·65	8·04	8·44	8·35	12·63	13·79

As regards phosphorus, the figures for the Indian ores are rather misleading; for an examination of the analyses from which these figures have been taken shows that the ores consist of two different varieties. The majority of analyses are typical of the ores of the Central Provinces, whilst four of them probably represent ores from the Vizagapatam district. I have accordingly separated them into two groups, of which the mean values are given in table 69. From these figures it will be seen that the Central Provinces ores average 0·096 per cent. and the Vizagapatam ores 0·291 per cent. in phosphorus. With the gradual rise that is taking place in the phosphorus contents of the ores won in the Central Provinces, however, it is probable that the average figure given in table 67 now corresponds closely with that for the Central Provinces.

Value of the Indian manganese-ore production.

The valuation of the Indian manganese-ore production is a question of some interest. There are of course several ways of stating the value. Manganese-ore possesses one value per ton as stacked at the pit's mouth, another as delivered *f.o.r.* at the railhead, a third as delivered *f.o.b.* on board the ship at the port of shipment, a fourth as delivered *c.i.f.* at the port of destination, and a fifth after it has been converted into ferro-manganese. For example, with the price at 21 pence per unit, the average value of 50 per cent.

TABLE 68.—*Mean of Analyses of Indian Ores in Table 67 arranged according to Probable Source.*

Source of ore.	Central Provinces and possibly Jhabua and Panch Mahals.	Vizagapatam.
Number of cargoes.	22	4
Manganese	51·31	45·95
Iron	5·53	10·29
Silica	6·13	3·10
Phosphorus	0·096	0·291
Moisture	0·71	0·76

Central Provinces ore, with 1923 data for freight charges, etc., may be taken as :—

Rs.	As.	
23	10	at the pit's mouth.
31	13	*f.o.r.*
48	1	*f.o.b.*
65	10	*c.i.f.*

The question of values is discussed at length in *Memoirs, Geol. Surv. Ind.*, Vol. XXXVII, Chapter XXV, and it is there shown that to obtain a true idea of the value of the industry to India the export or *f.o.b.* values must be considered. But it is also pointed out that the true value of the ore in the world's markets is the *c.i.f.* value. The export values formerly given were obviously much too low ; they were based on figures supplied by the mine operators, and represented, apparently, the cost of winning the ore and placing it on board a ship at the port, and not the true value of the ore, which is the *c.i.f.* value *minus* charges incurred from the port of shipment to the port of destination. In the work already cited the export values have been re-calculated from the beginning of the industry. First the *c.i.f.* values per ton have been calculated separately for each area, on the basis of the average market price per unit of manganese-ore during the year, and an assumed average composition of the ores. From these *c.i.f.* values the *f.o.b.* values are obtained by deducting freights *plus* destination charges from the *c.i.f.* value per ton. The *f.o.b.* value per ton is then multiplied by the actual production for the year. The figures thus calculated for the years 1909 to 1923 are given in table 69.

TABLE 69.—*Export value f.o.b. at Indian Ports of the Manganese-ore produced in India during the years 1919 to 1923.*

Year.	Bihar and Orissa.	Bombay.	Central Provinces.	Madras.	Mysore.	Total.	Value per ton.
	£	£	£	£	£	£	£
1919 . .	52,756	107,607	1,200,082	5,209	27,555	**1,393,209**	2·589
1920 . .	98,196	284,655	3,054,137	27,882	58,755	**3,523,625**	4·785
1921 . .	43,533	157,503	1,244,345	24,525	18,866	**1,488,772**	2·192
1922 . .	30,152	104,282	733,101	11,199	16,529	**895,263**	1·887
1923 . .	70,490	149,559	1,757,747	129,406	65,342	**2,172,544**	3·124
TOTAL .	**295,127**	**803,606**	**7,989,412**	**198,221**	**187,047**	**9,473,413**	..
Average .	*59,025*	*160,721*	*1,597,882*	*39,644*	*37,409*	*1,894,683*	*2·915*

There is, however, in many years a considerable difference between the amounts of ore won and the amounts exported; during the present quinquennium, in two years, namely 1919 and 1921 the amounts of ore won exceeded greatly the amounts of ore exported, whereas in the remaining three years the reverse relation held, the disparity being greatest in 1922. The totals obtained as above differ, therefore, considerably from the total values actually obtained by the mining community. As figures for the amounts of ore exported are not obtainable in detail province by province the totals may be adjusted for these years by valuing the exports for the calendar years ending 31st December at the average value per ton derived from the total production. Treated in this way the total values for 1919 to 1923 become—

	£
1919	959,118
1920	3,525,842
1921	1,207,272
1922	1,628,060
1923	2,656,412

and these figures have been used in the table of total values (table 1, page 6).

Comparing the export values of the manganese-ore production with the values for the other chief Indian mineral products given in table 1 it will be seen that manganese continues to occupy the fourth place.

Manufacture of ferro-manganese in India.

In earlier reviews reference was made to the potential loss that India suffers through exporting her manganese-ore in the raw condition, instead of converting at least a portion of it into ferro-manganese in the country. It was satisfactory, therefore, to be able to record in the previous review that during the war quinquennium the manufacture of ferro-manganese had been inaugurated in India. On account of the great increase in the price due to the war, one of the blast furnaces at Sakchi was diverted to the manufacture of ferro-manganese in October 1915, the average output from one furnace being about 80 tons a day. In 1917 the manufacture of ferro-manganese at Sakchi was discontinued on account of the necessity of keeping both blast furnaces on the production of pig-iron required

for the manufacture of steel. The average composition of the ferro-manganese produced was :—

	Per cent
Manganese	70
Phosphorus	0·55—0·66
Silicon	2—3

From November 1917 one of the smaller blast furnaces of the Bengal Iron Company at Kulti was engaged in the production of ferro-manganese with a guaranteed minimum of 74 per cent. manganese and maximum of 0·55 per cent. phosphorus. The average monthly output was given as 1,150 tons, and the balance left over after satisfying the requirements of Sakchi, was exported, the total exports (to France, United States, Italy, and Natal) up to the end of August 1918 being 7,555 tons. With the cessation of the war the production of ferro-manganese was discontinued at Kulti and resumed at Sakchi. The production of ferro-manganese in India during the quinquennium is shown in Table 70.

TABLE 70.—*Production of Ferro-Manganese in India during the years 1919 to 1923.*

Year.	Tata Iron and Steel Co.	Bengal Iron Co.	Total.
	Tons	Tons.	Tons.
1919	2,650	4,731	**7,381**
1920	1,183	*Nil.*	**1,183**
1921	3,076	*Nil.*	**3,076**
1922	1,810	*Nil.*	**1,810**
1923	3,506	*Nil.*	**3,506**
TOTAL .	12,225	4,731	**16,956**
1915 18	5,976	14,371	**20,347**

The ore used at Sakchi was in part railed from the company's mines in the Central Provinces, the average composition of the ore railed during 1917 being as follows:—

	Per cent.
Manganese	50·41
Iron	6·38
Silica	4·36
Phosphorus	0·041

That smelted at Kulti was purchased from the Central Provinces Prospecting Syndicate, but figures of composition have not been obtained.

The composition of the coke used at the two works was as follows:—

—	Sakchi.	Kulti
	Per cent.	Per cent
Moisture	6·54	2·2
Volatile matter	1·63	7
Fixed carbon	72·28	..
Ash	19·53	20
Sulphur	0·64	.
Phosphorus in ash	0·935	..

As will be seen from the figures given above the phosphorus contents of the alloy produced at Sakchi and Kulti were considerably higher than the figure 0·30 per cent. representing the upper limit of phosphorus acceptable abroad in normal times. With a careful selection of Indian ores (*e.g.*, of the composition of that already smelted at Sakchi, or ore from Balaghat running 0·07 per cent. phosphorus) and the use of Giridih coke running only 0·022 per cent. phosphorus, ferro-manganese could be produced with phosphorus within this figure. But considering that the amount of Giridih coke is limited, that Indian cokes are normally high in phosphorus, and that the percentage of phosphorus in the high-grade manganese-ores of the Central Provinces is slowly increasing with depth from the surface, it is evident that India can never be a large producer of low-phosphorus ferro-manganese by blast-furnace methods. The possibilities of the electric production of such low-phosphorus alloy deserve, therefore, careful consideration.

TABLE 71.—*Statistics of Manganese-ore received and consumed at the Iron and Steel Works of India.*

(Statute Tons.)

	TATA IRON AND STEEL CO.			BENGAL IRON CO.			INDIAN IRON AND STEEL CO.		
	Ore received.	Ore consumed.	Ore sold.	Ore received.	Ore consumed.	Ore sold.	Ore received.	Ore consumed.	Ore sold.
1913 (up to and including) .	9,901	8,561	.	615	..	..	..	..	..
1914	6,792	7,804	..	1,122	..	..	..	..	..
1915	21,066	12 485	60	1,254	..	..	..	..	..
1916	5,646	8,137	1	1,389	..	..	..	..	..
1917	*Nil*	6,356	..	10,326	..	..	..	..	..
1918	31,839	5.748	..	31,746	..	..	..	..	..
1919	81,737	8,637	..	4,748	..	..	..	..	..
1920	19,849	5,414	..	4,580	..	..	..	..	..
1921	*Nil*	15,885	..	1,138	..	..	..	..	..
1922	20,799	8,864	..	5.070	..	..	307	81	*Nil*
1923	*Nil*	16,175	36,061	3,558	..	..	2,229	2,144	*Nil*
TOTAL .	196,829	104,066	36,061	65,546	63,896	*Nil*	2,536	2,225	*Nil*

	Tons.
Total ore received	264.911
Total ore consumed	180,187
Total ore sold	36,061
Total ore stocks December 31st, 1923	48,663

The fact that ferro-manganese is now being made in India renders it important to secure statistics of the amounts of manganese-ore railed to Tatanagar and Kulti and consumed in India, in order to enable one to deduce what portion of the difference between the figures of production of manganese-ore in India and exports thereof represents accumulated stocks. These data are collected in Table 71, from which it will be seen that the total quantity of ore railed to Tatanagar, Kulti, and Burnpur, up to 31st December 1923 is 264,911 tons, of which 180,187 tons have been consumed, and 36,061 tons resold, leaving stocks of ore at the works amounting to 48,663 tons. It must be mentioned that manganese-ore is used not only in the manufacture of ferro-manganese, but is also added to the blast furnace charge in the manufacture of pig-iron, and in the open-hearth furnaces. Thus the Tata Iron and Steel Co. during the past quinquennium consumed 29,772 tons of manganese-ore in the manufacture of pig-iron, 20,486 tons in the manufacture of ferro-manganese, and 4,717 tons in the open-hearth steel furnaces.

Other economic considerations.

The thoroughness with which India was prospected for deposits of manganese-ores during the first 8 years or so of this century is shown by the fact that, during the quinquennial period, 1909-13, no fresh fields of importance were discovered, nor were any new deposits of importance located in areas already under exploitation; whilst during the succeeding period one fresh deposit only was opened up, namely Pani in Chhota Udepur, Bombay Presidency, the initial production of which dates from 1914, and which has yielded over 100,000 tons of ore during the present quinquennium. During the period now under review certain quantities of manganese-ore have been discovered in the iron-ore tracts of Keonjhar State, in Orissa, and there was a small initial production in 1923.

As before, work has been continued almost everywhere on open-cast lines; it was recorded in the previous review, however, that underground mining had been commenced at Kandri in the Nagpur district, and at Gariajhor in Gangpur: during the present period underground development has also been undertaken at the Balaghat mine.

With regard to the effects on output of the steadily increasing depth of the Indian manganese quarries, as would be expected, deposits of superficial origin, such as those of Vizagapatam, are, with the passage of years, giving a markedly decreased yield. But

deposits of the gond tic type (chiefly in the Central Provinces) show no evidence of deterioration in depth, except when structurai factors intervene, and except, also, for the very slight decrease in manganese contents and slight rise in silica and phosphorus contents that characterise many of these deposits, which features may, as noted in a previous review, be regarded as evidence of a certain amount of surface modification of these ores, originally consolidated in depth. With the continuous output of ore still yielded by so many of the Central Provinces deposits the mining companies have not yet been impelled to test, by boring, the continuity of their deposits in depth.

As already reported, the previous quinquennium witnessed the abandonment of an important deposit of the gonditic type, namely, Kajlidongri in Jhabua State. The year 1919 saw the abandonment (except for surface boulder accumulations) of a second valuable gonditic deposit, namely, Sitapar in the Chhindwara district. This deposit was worked from a large open quarry, until at about 100 feet from the surface the ore-body was truncated by felspathic intrusives. The circumstances render it possible that the remainder of the ore-body may lie concealed underground in one or more fragments.

From the commencement of work in 1906 until the end of 1921 the Sitapar deposit has yielded 70,600 tons of ore of exceptionally high grade, and in addition no less than three minerals new to science (see also page 232).

As several of the ores of manganese are distinctly magnetic, though usually only slightly so, it seems desirable to determine the possibilities of magnetometric surveying in locating the position of underground bodies of manganese-ore. The prospects of success in such application of these methods do not seem very bright; but this much has been already ascertained, that a dipping-needle set up directly on a manganese-ore deposit is often strongly affected thereby.

Geological Relations of Indian Manganese-ores.

In view of the importance of the Indian manganese industry it is proposed to repeat below, with such slight alterations as are

necessary, the brief sketch of the distribution and mode of occurrence of the Indian deposits given in the previous review. The deposits of economic value can be divided into three main groups.—

(*A*) Deposits associated with rocks of Dharwar age—the manganiferous facies of which is known, when containing spessartite-garnet, as the *gondite* series. Found in—

Bihar and Orissa :—*Gangpur.*
Bombay :—Narukot, *Panch Mahals, Chhota Udepur.*
Central India :—*Jhabua.*
Central Provinces :—*Balaghat, Bhandara, Chhindwara, Nagpur* and Seoni.

(*B*) Deposits associated with a series of manganiferous intrusives known as the *kodurite* series. Found in—

Madras :—Ganjam, *Vizagapatam.*

(*C*) Deposits occurring as *lateritoid* replacement masses on the outcrops of Dharwar rocks. Found in—

Bihar and Orissa :—*Keonjhar, Singhbhum.*
Bombay :—Dharwar, North Kanara, Ratnagiri.
Central Provinces :—*Jubbulpore.*
Goa.
Madras :—*Bellary, Sandur.*
Mysore :—*Chitaldrug, Kadur, Shimoga, Tumkur.*

(Italics denote that ore has been worked for export.)

In addition to the occurrences noted above, ore has been worked in the low-level laterite of Goa and the high-level laterite of Belgaum (though this occurrence—Talevadi—might perhaps be more accurately classed with the lateritoid occurrences). Manganese-ores have also been found in many other districts in India, but none of these other occurrences has been shown to be of any value. Amongst them, the following may be mentioned :—

In Bijawar rocks :—Dhar, Gwalior, Indore, Hoshangabad.
In Vindhyan rocks :—Bhopal.
In Kamthi rocks :—Yeotmal.
In Lameta rocks :—Dhar, Indore, Nimar.
In lateritic soil on the Deccan Trap :—Satara.

Each of the three chief groups will now be considered in turn,

A.—The Gondite Group.

The gondite series.

The gondite series[1] is composed of metamorphosed manganiferous sediments of Dharwar age, and is characterised by the presence of various manganiferous silicates, the most important of which are the manganese-garnet, spessartite, and the manganese-pyroxene, rhodonite. The garnet occurs commonly as a rock composed of spessartite and quartz, and this is the rock that has been called *gondite*, after the Gonds, one of the aboriginal races of the Central Provinces. Other common rocks are spessartite-rock, rhodonite-rock, and rhodonite-quartz-rock. The series is developed typically in the districts of Balaghat, Bhandara, Chhindwara, and Nagpur, in the Central Provinces, but has also been found in several other areas, namely :—Narukot State in Bombay, Jhabua in Central India, Gangpur State in Bihar and Orissa, and probably in Banswara State in Rajputana. It exists also in the Seoni district, Central Provinces.[2]

Forming an integral portion of the same masses of rock as the gonditic rocks, there are, at many places, bodies of manganese-ore, often of large size and first-rate quality, some of the manganese-ore deposits of the Central Provinces being the most valuable in India, and second to none found in other parts of the world.

Origin.

The rocks of the gondite series are supposed to have been formed by the metamorphism of a series of sediments deposited during Dharwar times. These sediments wêre partly mechanical (sands and clays) and partly chemical (manganese oxides). When these sediments were metamorphosed, the sands and clays were converted into quartzites, mica-phyllites and mica-schists; the purest of the manganese-oxide sediments were compacted into crystalline manganese-ores; whilst mixtures of the mechanical sediments, sand or clay, with the chemical sediment, manganese oxide, were converted into rocks composed of manganese silicates—spessartite and rhodonite—any silica left over, after accounting for the formation of these minerals, appearing as quartz. [The effects of regional metamorphism have been in some cases complicated by contact effects with resultant hybridism due to later intrusives.[3]] The rocks thus formed constitute the *gondite series*. There is abundance of evidence to prove that the manga-

[1] *Mem. Geol. Surv. Ind.*, XXXVII, pp. 306—365.
[2] R. C. Burton, *Rec. Geol. Surv. Ind.*, XLIV, p. 21, (1914).
[3] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XLV, p. 104, (1915).

nese-silicate-rocks of the gondite series have been subjected to extensive oxy-alteration, subsequent to their formation, but probably in Archæan times. As a result of this alteration large bodies of manganese-ore have been formed; no decisive evidence has yet been obtained indicating the relative proportions of the workable ores that are the result of the direct compression of the purer portions of the original manganese-oxide sediments[1] and of the ores that have been formed by the subsequent alteration of the rocks of the gondite series.

Nagpur-Balaghat area: mode of occurrence.

The ore-bodies thus formed occur as lenticular masses and bands intercalated in the quartzites, schists, and gneisses; and, as would be expected from the suggested mode of origin, the ore is frequently found to pass, both laterally and along the strike, into the partly altered or quite fresh members of the gondite series, the commonest rock being gondite itself. The ore-bodies are often well-bedded parallel to the strike of the enclosing rocks, and several of them are often disposed along the same line of strike, indicating that they have probably all been produced from the same bed of manganiferous sediment. A good example of such a line of deposits is one in the Nagpur district, stretching from Dumri Kalan in an easterly direction as far as Khandala, a total distance of 12 miles, this line including the valuable deposits of Beldongri, Lohdongri, Kacharwahi, and Waregaon. With the enclosing rocks the ore-bodies have often suffered repeated folding, upon which is often superposed a well-marked pitch, which frequently, as at Kandri and Thirori, determines the direction of mining operations.

Dimensions of ore-bodies.

The ore-bodies often attain great dimensions. The Balaghat deposit is $1\frac{3}{4}$ miles long; at Manegaon in the Nagpur district the ore-body is $1\frac{1}{2}$ miles long; whilst the band running through Jamrapani, Thirori, and Ponia, in the Balaghat district, is exposed more or less continuously for nearly 6 miles. In an earlier review a thickness of 100 feet (of ore) was ascribed to the Kandri deposit, and of 1,500 feet (ore and gonditic rocks) to the Ramdongri deposit. Subsequent work indicates that both these deposits are folded, and

[1] The fact that some of the gonditic manganese-ores are of great antiquity (at least pre-pegmatite in age) was conclusively proved by the discovery of a detached fragment of ore in pegmatite cutting the Gowari Warhona manganese-ore deposit, Chhindwara district. See *Rec. Geol. Surv. Ind.*, XLI, pp. 1—11, (1911). Similar phenomena were later well displayed at Sitapar in the same district, and are still to be seen at intervals at Kachhi Dhana.

there is no evidence that the ore-bodies are anywhere more than 45 to 50 feet thick : a greater apparent thickness appears to be due to repetition by folding. On the other hand the ore-band is often much thinner, but may have again attained a fictitious thickness due to folding. The depth to which these ore-bodies extend is unknown. It is, however, almost certain that, in many cases, they extend to at least 100 to 400 feet below the outcrop, *e.g.*, some of the deposits occupying hills in the Central Provinces ; and it is very probable that some of the Central Provinces deposits extend to depths considerably greater than these ; for the evidence obtained indicates that the deposits were formed in depth, so that the position of the deposit bears no genetic relation to that of the surface. An idea of the size of some of these deposits can be obtained from the amounts of ore they have yielded, as shown in the following table :—

TABLE 72.—*Total Production of Manganese-ore from Deposits of Gonditic Type that have yielded 100,000 tons of ore by the end of 1923.*

—	Mine.	District or State in which situated.	Year of commencement of work.	Total production to end of 1923.
1	Balaghat	Balaghat	1901	1,265,318
2	Kandri	Nagpur	1900	879,662
3	Thirori	Balaghat	1902	837,458
4	Chikhla (with Yedarbuchi).	Bhandara . .	1901	756,974
5	Kachi Dhana . .	Chhindwara . .	1906	642,749
6	Mansar	Nagpur	1900	556,610
7	Kodegaon . .	Do.	1903	339,287
8	Gumgaon	Do.	1901	313,678
9	Lohdongri . .	Do.	1900	303,986
10	Gariajhor . .	Gangpur	1908	277,554
11	Miragpur	Balaghat	1905	275,920
12	Sukli	Do.	1905	239,472
13	Sitasaongi . .	Bhandara . .	1908	205,235
14	Kailidongri . .	Jhabua	1906	195,763
15	Ukua (with Samnapur and Gudma).	Balaghat . .	1906	181,381
16	Satak	Nagpur	1904	130,685
17	Ramrama . .	Balaghat	1906	122,810
18	Junawani	Nagpur	1906	116,144
19	Kosumba	Balaghat	1905	114,163
20	Shodan Hurki . .	Do.	1912	107,542
21	Kacharwahi . .	Nagpur	1902	106,905

N.B.—Manegaon (Nagpur) and Netra (Balaghat) have nearly reached 100,000 tons.

The total production from deposits of the gonditic type (the Central Provinces, Jhabua, and Gangpur) averaged 525,192 tons annually during the quinquennium as compared with 504,597 tons annually during 1914-18, and 529,152 tons during 1909-13.

Composition of ores.

The typical ores of the Nagpur-Balaghat area of the Central Provinces consist of mixtures of braunite and psilomelane of different degrees of coarseness of grain. The most typical ore is a hard fine-grained ore composed of these two minerals. Other minerals found in the Central Provinces ores are hollandite, vredenburgite, sitaparite, and rarely pyrolusite. The unique ore of Sitapar in the Chhindwara district consisting of hollandite with sitaparite and fermorite, proved to be a surface form, and at a depth of 60 feet gave place almost entirely to braunitic ore, which persisted to the bottom of the pit at 100 feet (see page 227). The ores exported from the Central Provinces are nearly all of first grade, although at times of high prices, a small quantity of second-grade ore is exported. The chief characteristics of these ores are the high manganese contents (usually 48 to 54 per cent. as exported), moderately high iron (usually 4 to 8 per cent.), rather high silica (usually about 6 to 9 per cent., and largely due to the braunite in the ore), and moderately low phosphorus (about 0·07 to 0·17 per cent.). For analyses see table 66, page 216.

Ores in crystalline limestones.

In addition to the deposits found in association with spessartite- and rhodonite-bearing rocks in the Central Provinces, manganese-ores are sometimes found in association with crystalline limestones, usually containing piedmontite, and also regarded as of Dharwar age. Ores of this character are found characteristically in the Nagpur and Chhindwara districts. The manganese-ores occur either as lines of nodules or as fairly definite beds in the limestone, the latter being the rarer mode of occurrence. In most cases it is not found profitable to work these ores; but where the bed of ore is of greater thickness than usual, as in the Junawani forest, it may pay at times of high prices; whilst patches of residual nodules accumulated during the dwindling of limestones will pay to work at any time, if not too far removed from transport facilities. The ores found thus are usually composed of braunite and psilomelane or hollandite. These ores, and the associated crystalline limestones and calcareous gneisses, are probably the products of the metamorphism

of calcareous sediments with associated manganiferous ores, and are thus analogous in origin to the ores associated with the true gonditic rocks.

The remarks in the foregoing paragraphs apply particularly to the deposits found in the Central Provinces, but also in a general way to the deposits found associated with rocks of the gondite series in other parts of India. A few remarks about these are given below.

Gangpur, Bihar and Orissa.

During 1908 the extension of the gondite series into Bihar and Orissa was proved by the discovery of manganese-ore deposits in Gangpur State associated with rocks containing spessartite and rhodonite. The ores are typical gonditic ores, containing braunite in a matrix of psilomelane. The chief deposit, Gariajhor, has yielded 277,554 tons of ore during the years 1908 to 1923. As will be seer from the figures summarised in the following table, the quality of the ore is similar to that of the Central Provinces :—

—	1909. Limits of analyses.	1909. Mean of analyses.	1919-1923. Average analysis of ore railed.	
Manganese	47·64 —54·13	50·53	49·60	45·85
Iron	5·53 — 6·35	5·85	7·82	8·29
Silica	2·6 — 8	5·7	4·96	5·04
Phosphorus	0·018— 0·143	0·089	0·205	0·144
Moisture	0·78 — 1·16	0·96	..	..

The 1909 figures relate to cargoes shipped during that year, the manganese and phosphorus figures representing eight analyses on a total of 3,600 tons of ore, and the other constituents four analyses on a total of 1,600 tons of ore. The 1919-23 figures, supplied by

Mr. W. H. Clark, represent the first and second grade ore as exported during the period. The estimated average figures are given in Table 65. These two sets of figures are of interest as illustrating the increase of phosphorus contents in gonditic ores with depth from the surface.

Narukot, Bombay.

Rocks of the gondite series with associated manganese-ore have been found in a smallhill at Jothvad in Narukot State, Bombay. The occurrence is of no economic importance, but of great scientific interest. The rock surrounding the hill is a porphyritic biotite-granite presumably of Archæan age, and apophyses from this pierce the gonditic rocks of the hill. Isolated pieces of gonditic rock are included in the granite, and amongst these inclusions are pieces of manganese-ore, proving that a portion at least of the manganese-ore had been formed before the time of intrusion of the granite into the Dharwar rocks of the area.

Panch Mahals.

Manganese-ore deposits are being worked near Shivrajpur and Bamankua in the Panch Mahals. The rocks with which they are associated are Champaners, that is Dharwars; no rocks of gonditic nature have been found in this area, but it seems, judging from reports, that although a portion of the ores has certainly been formed by the superficial replacement of quartzites, a portion may have been deposited contemporaneously with the enclosing Dharwar rocks; in this case the deposits may be classified with the gonditic deposits. The absence of gonditic rocks would then mean that the rocks—as at the Balaghat deposit in the Central. Provinces—had not been subjected to such intense metamorphism as that which produced the gonditic rocks associated with most of the Central Provinces deposits. 562,454 tons of ore have been won from this area in the eighteen years 1906 to 1923. The average composition of this ore as exported is shewn in Table 66.

Jhabua, Central India.

The chief deposit in Jhabua State was that situated at Kajlidongri. This is a true gonditic occurrence, and the rocks associated with the manganese-bearing rocks are those known as Aravallis, which are in this part of India the equivalents of the Dharwars. In the 12 years 1903 to 1915 this deposit yielded 195,763 tons of manganese-ore, and since 1916 the deposit has been abandoned. For the quality of the ore obtained see Table 65.

B.—The Kodurite Group.

Kodurite series.

The kodurite series[1] is developed typically in the Vizagapatam district, where it occurs associated with other Archæan crystalline rocks, the chief groups of which are the khondalite series including the calcareous gneisses or granulites, the gneissose granite, and the charnockite series. The kodurite series is held to be of igneous origin, and probably of later age than the khondalite series, which is the series with which it is closest associated. The original koduritic magma has been differentiated into a series of rocks ranging from very acid (quartz-orthoclase-rock through basic (kodurite) to ultra-basic (spandite rock and manganese pyroxenites). The typical rock, *kodurite*, is composed of potash-felspar, spandite (a garnet intermediate in composition between spessartite and andradite), and apatite. The manganiferous nature of these koduritic rocks has been a petrological surprise, and it has consequently been suggested[2] that they may be hybrid rocks produced by the assimilation by an acid igneous magma of manganese-ore bodies and manganese-silicate-rocks allied perhaps to the gondite series.

The manganese-bearing minerals contained in these rocks are spandite, rhodonite, and two or three other manganiferous pyroxenes, at present unnamed. Subsequently, the whole series of rocks has been chemically very much altered with the production from the felspar of enormous masses of lithomarges and, from the manganiferous silicates, of manganese-ores. Other secondary products are chert, ochres, and wad.

Vizagapatam: mode of occurrence.

The manganese-ore bodies thus formed are often extremely irregular both in shape and size, often showing no definite strike or dip. But in other cases, as at Garbham, the ore-bodies have a well-marked dip and strike, and apparent bedding, which probably represents original banding in the parent rock; for much of the ore has been deposited so as to replace metasomatically the pre-existing rock.

[1] *Mem. Geol. Surv. Ind.*, XXXVII, Chaps. XII, XIII, (1909); *Rec. Geol. Surv. Ind.*, XXXV, p. 22, (1907); *op. cit.*, XLII, p. 208, (1912); *op. cit.*, XLIII, p. 42, (1913).

[2] *Rec. Geol. Surv. Ind.*, XLV, p. 102, (1915). Also see Whitman Cross, *Journ. Geol.*, XXII, pp. 791—806, (1914).

Dimensions of ore-bodies.

Some of the ore-bodies are of very large size. The largest, Garbham, is some 1,600 feet long, and 167 feet thick at its thickest section 100 feet of this thickness being ore and the remainder lithomarge, wad, etc. From the commencement of work on this deposit in 1896 to the end of 1923, Garbham has yielded the large total of 810,164 tons of ore. The only other very large deposit in this district is Kodur; but this is really a series of scattered ore-bodies in lithomarge. It has yielded 392,591 tons of ore from 1892 to 1923. It was the first manganese-ore deposit to be worked in India.

Composition of ores.

The ores of the Vizagapatam district are composed mainly of psilomelane with subordinate amounts of pyrolusite, braunite, manganmagnetite, and in one case (Garividi) vredenburgite. They are usually of second and third grade—although some first-grade ore has been obtained at Kodur—and can be divided into manganese-ores (above 40 per cent. Mn) and ferruginous manganese-ores (below 40 per cent. Mn). They are characterised by high iron and phosphorus contents, and comparatively low silica (see Table 66).

C.—The Lateritoid Group.

Lateritoid deposits.

In several parts of India manganese-ore deposits are found on the outcrops of rocks of Dharwar age, associated with the latter in such a manner as to leave little doubt that the ores have been formed by the replacement at the surface of Dharwar schists, phyllites, and quartzites. The masses of ore thus formed do not consist entirely of manganese-ore, but often contain considerable quantities of iron-ore; and every gradation is to be found from manganese-ores, through ferruginous manganese-ores and manganiferous iron-ores, to iron-ores. The masses of ore thus formed are often more or less cavernous and bear considerable resemblance to ordinary laterite. In fact some geologists would designate such occurrences by this term; but others would object: and, therefore, to obviate this difficulty the term *lateritoid*—meaning *like laterite*—has been introduced to designate this class of deposit. Lateritoid deposits are, then, irregular deposits of iron and manganese-ores, occurring on the outcrops of Dharwar rocks, and resembling in their cavernous and rugged

aspect masses of ordinary laterite. When the rock replaced is a schist or phyllite, it is usually found altered to lithomarge below the capping of ores. The mineral composition of the ores thus formed is usually fairly simple. The manganese-ores are pyrolusite, psilomelane, wad, and more rarely pseudo-manganite, and manganite; whilst the iron ores are limonite and earthy hematite. The harder crystalline minerals—braunite, vredenburgite, sitaparite, magnetite, and specular hematite—are found rarely or never in the lateritoid ores. Hollandite may sometimes occur. The chemical characteristics of the manganese-ores are high iron, low silica, and often very low phosphorus. The manganese is usually correspondingly low, so that the ores won consist mainly of second-grade manganese-ores and third-grade ferruginous manganese-ores. Such deposits will be worked to the greatest advantage when a market can be found for the iron-ores and manganiferous iron-ores, as well as for the manganese-ores.

Singhbhum and Jubbulpore.

The areas where ores of this nature have been found are given on page 228. Singhbhum and Jubbulpore, and in 1923 Keonjhar State, have yielded small quantities of merchantable ore, but the most important of the lateritoid areas are Sandur and Mysore. A large number of deposits, many of them of large size, have been located in the Sandur Hills, mostly perched up on the edge of the hills at an average elevation of about 1,000 feet above the plains.

Sandur.

When transport difficulties have been surmounted, these deposits may be expected to yield large quantities of second-grade and third-grade ores, with possibly a certain proportion of first-grade ore from the Kamataru portion of the State. The deposits are being worked by the General Sandur Mining Company, Ltd. During the years 1905 to 1914, 418,424 tons of ore were won from these deposits, mainly from the Ramandrug and Kannevihalli areas, but work was closed down during the war on account of the high ocean freights. In 1921 work was resumed by this company and 39,355 tons of ore were estimated during the quinquennium making a total of 457,779 tons since the beginning. For analyses see Tables 65 and 66.

Mysore.

The manganese-ore deposits of Mysore are numerous, but very few of them can compare in size with those of the Sandur Hills, although they have been formed in the same way. The chief exception is the Kumsi deposit in the

Shimoga district, from which some 160,000 tons of ore were won in the three initial years 1906 to 1908, the State as a whole yielding 228,243 tons during the same period. In the quinquennium 1909-13 there was a great decline in output compared with that of the initial period of work. the average annual output of the State being 28,280 tons. The subsequent decline has been at a much smaller rate, the average annual output for the quinquennia 1914-18 and 1919-23, being respectively 24,205 tons and 21,703 tons. The reduction of the industry to the lower level of the last 15 years is largely due to the superficial nature of the deposits leading to early exhaustion of the best class of ores, whilst high railway and sea freights prevent the exploitation of the lower grade ores. The chief company at work in this State is the United Steel Companies, Limited, which took over the Workington Iron Company, Ltd., in 1918.

The Laterite Gruop.

Goa and Belgaum.

Manganese-ores are sometimes found in true laterite; but such ores are rarely of much economic value. The ores of Goa (Portuguese India) occur in part in this way (in low-level laterite), as also those of Belgaum (in high-level laterite). They are not economically of great importance, owing to the irregular manner in which they occur, and their extremely variable composition. Picked ores, however, are similar in composition to the picked lateritoid ores. Only 154 tons of ore won in Goa were exported from Mormugao during the period 1919-23 as compared with 598 tons during the war period and 16,243 tons in the previous quinquennial period. These exports are, of course, excluded from Table 57.

No figures have been obtained of the production of manganese-ore in Goa during the present period.

Mica.

[C. S. Fox.]

Varieties.

The chief micas of commercial value are those which are practically transparent in relatively thin plates. These may be pale-tinted and clear or only slightly stained and spotted. The two chief varieties both from a

mineralogical and economic aspect are *muscovite* and *phlogopite*. With the exception of a very small production of *phlogopite* from the workings in Travancore, nearly all the mica extracted from the pegmatitic rocks of the mica occurrences of India belong to the variety known as *muscovite*.

Production and Exports.

The annual Indian production of mica is at least equal to the total output from all other countries. It is not surprising, therefore, to discover that for over 25 years India has been the biggest producer of mica. However, practically all the Indian mica is exported to Europe and America, the domestic consumption being certainly less than 2,000 cwts. annually.

The Indian exports of mica during the period 1919-23 are shown in the accompanying Table 73. In this it is noticeable that the prices have fallen considerably. Thus in 1919 the average price per cwt. was Rs. 146-1-8, roughly Re. 1-5-0 per lb., as against Rs. 96-15-4, about Rs. 0-13-10 per lb., in 1923. There has also been a decided falling off in the exported quantities to the United Kingdom.

TABLE 73.—*Exports of Indian Mica during 1919-23.*

		1919.	1920.	1921.	1922.	1923.
Blocks	Cwts.	(a)	(a)	4,011	9,001	12,401
	Rs.			18,42,469	17,80,494	16,46,944
Splittings	Cwts.			17,651	34,144	70,895
	Rs.			32,15,314	40,04,751	64,29,578
TOTAL	Cwts.	59,098	76,517	(b) 30,944	43,145	83,296
	Rs.	86,34,480	1,06,54,380	63,94,113	57,85,245	80,76,522

(a) Separately recorded since April 1921.
(b) Details of blocks and splittings are incomplete. The total figure represents exports during nine months, April to December, 1921.

Whither consigned.		1919.	1920.	1921.	1922.	1923.
United Kingdom	Cwts.	54,177	46,300	19,376	15,905	20,213
	Rs.	79,26,330	61,42,050	36,39,165	24,47,925	24,14,177
United States	Cwts.	3,872	27,056	8,304	18,234	52,886
	Rs.	6,17,580	41,89,380	22,69,075	23,56,501	46,20,368
Germany	Cwts.	..	..	1,469	5,752	5,822
	Rs.	..	..	1,90,193	5,56,819	4,64,449
Other countries	Cwts.	1,049	3,161	1,795	3,254	4,375
	Rs.	90,570	3,22,950	2,95,680	4,24,000	5,77,528

From the above table it is also seen that trade appears to have been steadily improving during the favourable exchange period (1919-20) which immediately followed the signing of the Armistice. The mica industry, however, suffered in the year 1921 when a general slump settled on trade generally. Matters, with regard to mica exports, improved during 1922, and the demand for Indian mica, particularly mica-splittings, became brisk in 1923 in spite of the fall in prices. This smaller average value per cwt., to which attention has already been drawn, is due largely to the smaller sizes of mica which are being exported.

A curious feature becomes evident when the figures for export, given in the above table, are compared with the returns for production from Indian workings seen in Table 74. The Indian exports of mica are seen to be considerably in excess of the reported production. This has been ascribed partly to the incomplete production returns and partly to illicit buying and selling of mica in the chief mica producing areas.

TABLE 74.—*Production of Mica in India during 1919 to 1923.*

PROVINCE.	1919.		1920.		1921.		1922.		1923.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Cwts.	*Rs.*	Cwts.	*Rs.*	Cwts.	*Rs.*	Cwts.	*Rs.*	Cwts.	*Rs.*
Bihar and Orissa	34,230 2	*15,96,781*	32,883·5	*16,28,707*	26,058	*12,67,815*	29,400 8	*10,49,573*	23,813	*11,76,476*
Central Provinces	..	..	0·3	*12*	..	..	100	(*a*)	..	..
Madras . .	8,320 6	*5,25,800*	11,927·8	*6,14,414*	4,376	*2,10,445*	1,301·2	*95,481*	8,814	*3,38,615*
Mysore . .	..	..	55 2	*2,125*	182	*4,273*	135·7	(*a*)	(*b*) 48·7	*1,757*
Rajputana .	3,232 9	*75,845*	2,085 7	*1,05,517*	1,872	*1,11,033*	940 4	*57,650*	1,179 5	*71,097*
TOTAL .	45,783·7	*21,98,426*	46,952·5	*23,50,775*	32,488	*15,93,566*	31,878 1	*12,02,704*	33,855·2	*15,87,945*
Value in sterling		£191,167	..	£235,077	..	£106,238	..	£80,180	..	£105,863
		(£1=Rs. 11·5)	..	(£1=Rs. 10)	..	(£1=Rs. 15)	..	(£1=Rs. 15)	..	(£1=Rs. 15)

(*a*) Not available.
(*b*) Excludes 370·7 cwts. of rough mica.

Localities.

By far the greatest quantity of mica is obtained from the workings in the so-called Bihar mica belt, which trends across parts of the districts of Hazaribagh, Gaya and Monghyr. Almost all the mica from that region finds its way down to Calcutta and is shipped from that port. The output of mica from the Nellore mines of Madras is normally exported from the port of Madras, while the annual production from Travancore, Mysore, and Rajputana usually finds its way to Bombay, where it is finally shipped for export abroad. Bihar and Orissa being the largest producer of mica, as seen from the table of production, it is evident that the exports will be largest from the port of Calcutta.

Imports.

During the last three years there are returns (see Table 75 below) which show that a certain amount of mica—chiefly block mica—has been *imported* into India from the United Kingdom, the United States and Japan. In view of the brisk demand for mica splittings it is to be concluded, therefore, that this mica, whether it be Indian mica returned to this country or foreign mica, has been received for conversion into fine splittings and would then be re-exported as splittings.

TABLE 75.—*Imports of Mica during 1921 to 1923.*

		1921.	1922.	1923.
Blocks	Cwts.	3,187	1,951	3,204
	Rs.	5,93,593	1,83,936	2,21,122
Splittings	Cwts.	845	56	267
	Rs.	1,44,961	15,559	10,414
TOTAL	Cwts.	**4,032**	**2,007**	**3,471**
	Rs.	**7,38,554**	**1,99,495**	**2,31,536**

The production of fine splittings by hand is an art which is performed to perfection in India and is carried out at considerably less expense than would be possible in European countries.

The chief mica mining areas in India are those of Hazaribagh in Bihar and of Nellore in Madras. Mica has also been obtained from workings in the Eraniel taluk of Travancore, the Hassan district of Mysore and Ajmer in Rajputana.

Indian Mica Occurrences.

The "mica-belt" of Bihar obliquely traverses the districts of Gaya, Hazaribagh and Monghyr, along a strip about 12 miles broad and over 60 miles long. A large number of the more important workings are situated either in or in the vicinity of the Kodarma forest. The local names of Kodarma, Domchanch, Dhab, Gawan, Tisri, etc., are familiar to mica dealers in London and elsewhere. By far the larger proportion of the Indian output of mica is obtained from the Bihar mica-belt, although the mica is often commercially spoken of as Bengal mica or Bengal ruby mica[1] because the sheets in sufficient thickness have a beautiful ruby colour—a characteristic of the muscovite from the Hazaribagh district. Another but secondary characteristic of the area is the fact that garnets found in association with mica in Bihar occur in the crystal habit known as the icositetrahedron.

The mica mines of the Nellore district of Madras are situated on the eastern half of the Madras coastal plain between latitudes 14° and 15°, over a tract of country some 60 miles long and 8 to 10 miles broad. As in the Bihar belt, where beside primitive burrowings there are modern mines, so in the Nellore district, although the great majority of the mines are merely open quarries, Tel'abodu, Kalichedu and some other mines are worked on up-to-date lines. Madras mica generally has a characteristic green colour thought to be due to traces of chromium in the muscovite from that area. However, brown mica, not unlike ruby, occurs at Kalichedu and along the pegmatite strike there. Associated with the mica are, as will be seen below, several minerals, amongst which are to be seen garnet crystals in the dodecahedral habit. The garnets of both Nellore and Hazaribagh are of the same variety although they have different crystal shapes.

The distinction which is apparent in the prevalent methods of working in Bihar and Madras, is also noticeable in the preparation of mica for the market in the two areas. In the Bihar belt all the mica is sickle-trimmed into irregularly shaped blocks while the Nellore mica (with the exception of that of Kalichedu which is

[1] Dating from the days before the province of Bihar and Orissa was formed.

sickle-trimmed) is trimmed by shears into rectangular shapes and classified and sized with meticulous care for excise purposes. The Bihar block mica is thicker than the shears-trimmed Madras material.

There is a great similarity in the mode of occurrence of mica in pegmatites throughout India and it is thought that a description of the mining operations undertaken by the Geological Survey of India at Jorasemar near Kodarma on behalf of the Ministry of Munitions, London, may not be out of place. The workings were opened late in 1917 and closed under the charge of the writer in 1919.

Government Mica Mines, Jorasemar.

The prevailing rocks at Jorasemar are varieties of mica-schist in a narrow strip which terminates about 1½ miles to the east of Jorasemar camp. The mica-schist band is about a mile broad from north to south at the camp itself and trends away westward to join the large area of mica schists in the Government Reserve forest north of Kodarma.

At Jorasemar the mica-schists appear to lie in a synclinal fold of the gneisses of Bihar. The foliation strike of both gneisses and mica-schists is invariably east to west. The foliation dips are usually very steep, frequently vertical, in some exposures northward and in others to the south. Local variations in strike and dip are by no means uncommon—anticlinal pitching folds, evidences of puckering and apparent thrust-faulting in miniature being often observed at various places.

Irregular, elongated, lenticular outcrops of pegmatite traverse both the gneisses and mica-schists. There is usually a parallelism between the strike of the pegmatites and the foliation planes of the enclosing gneisses or schists. Pegmatites may, however, traverse the foliation planes obliquely or even at right angles. As a result of experience the local miners have discovered that it is useless as a rule to look for mica of workable quantity and quality in those pegmatites which traverse the gneisses or in those schists which are markedly non-micaceous.

Most of the marketable mica of the Hazaribagh district appears to be won from pegmatites traversing mica-schists. It does not stand to reason that all pegmatites which traverse mica-schists are worth exploiting. They are not. Each pegmatite varies in the value of its marketable mica-content and the latter can only be determined by actual exploration.

The tendency, therefore, is to associate the mica, which is worth mining, with areas in which mica-schists occur and to prospect pegmatites which traverse these mica-schists. This association holds good in many parts of the district.

The pegmatites of Jorasemar have been found to be exceedingly erratic both in continuity and shape. They, however, have one common feature, and this is that, though keeping a rough parallelism with the foliation planes of the enclosing mica-schists, they pitch or plunge down, at a slant to the dip of the foliation plane, in a direction always towards the west, *i.e.*, away from the point where the schists themselves pinch out.

None of these pegmatites have a greater thickness than 15 feet, and of those which have been worked to any considerable extent few continue more than 100 feet without change in strike, dip, thickness or in the richness or quality of their mica-bearing contents.

The area contains many pegmatites, some worthless from a mining point of view, others remarkably prolific in certain portions of the pegmatite. Some of the larger pegmatites are clearly associated with lines of faulting and special buckling of the schists. The faulting is shown by slickensided surfaces. The faults appear to have been formed before the larger mica crystals had developed—for the crystals though at times badly buckled and cleaved could not have survived the intense contortion to which the schists owe their origin, without complete destruction from a marketable standpoint.

Enrichments of mica are not uniform throughout the section of a pegmatite, nor are the minerals composing the pegmatites equally disposed. Pockets of isolated crystals of muscovite mica invariably occur to one side or other of the body of the pegmatite. The central mass of the deposit is usually composed of a core of granular, pelucid quartz in which beryl and tourmaline crystals may be totally enclosed. On each side of the quartz core there is usually a margin of felspar and it is, most frequently. at the junction of this felspathic margin and the central quartz core that the largest "books" of mica are found. Marketable mica is also to be found in certain pegmatites nearer the actual contact with the schists, either on the hanging or foot wall. Large crystals of garnet occur in about the same situation while tourmaline is common in the margin and in the quartz core. Apatite in varying quantities is found in almost every one of the larger pegmatites.

It was hardly possible to say from day to day how a working was going to turn out in the next three or four days, and this state of uncertainty continued to the day of closing down the mines. Out of at least 100 places which were either taken over from petty contractors, or re-opened from a disused condition or started as new ventures, only five shewed comparative steadiness for any length of time from the day they were put in working order.

As most of the pegmatites were of no great size, in nearly all cases each working place required its own entrance and separate arrangements for hoisting and pumping. In the larger pegmatites the shape and position of the rich mica-bearing portion were usually found to be so disposed that it was difficult to arrange for more than three or four working places.

The production of large quantities of mica, other things being equal, depends entirely on the number of productive working places. If the development has to be done on numerous small pegmatites, as detailed above, then working costs will be greater than those of the exploitation of an equal number of working faces in a single large pegmatite.

At Jorasemar the production simply depended on finding and opening up more and more working places. As labour became available the output steadily rose and the maximum output would have been reached when every possible workable pegmatite had been opened or when the maximum permissible expenditure was being incurred.

Practically no machinery was found necessary other than that worked by hand. Buckets and hand-pumps were found sufficient in dealing with the small quantities of water that accumulated in the workings. Shear-legs, a swinging derrick, a capstan, three crab winches and a few single sheave pulley-blocks comprised the most complicated forms of hoisting apparatus necessary for these simple mines.

In proportion to the development work, somewhat large quantities of explosives were used. Small and frequent charges of 40 per cent. dynamite were utilized in loosening the matrix in which the larger crystals of mica were embedded. These "shots" were so fired as to leave the mica undamaged and yet save the laborious chiselling that would otherwise have been necessary to get out the "books" intact. Candles were exclusively used for lighting.

There was also a heavy wear on the drills owing to the practice of prising up rock loosened by "shots"; breakages became so frequent that a portable forge had to be placed near the more distant workings and the *sirdars* warned that crow-bars were to be used in place of chisels.

Timbering was occasionally necessary in the mines, especially when working in the neighbourhood of slickensided surfaces. The mouths of many of the shafts had also to be secured by "collar sets," but most of the shafts were safe if thatched shelters were built over them to prevent rain beating in.

The rough books of mica were split or cleaved into thick plates at the mines and the worthless pieces thrown away. After hand-picking the plates were tied into bundles of about 50 lbs. weight each and carried to the godown where they were weighed and stored, the bundles of large mica being kept separate from the small or "*ruddi*" bundles.

Each morning "rough mica" was issued to the cutters for sickle-trimming. Useless pieces were cut away, flaws removed and rough-dressed plates of block mica obtained. On an average 100 cutters, of varying degrees of efficiency, were able to deal with 50 *maunds* of Jorasemar mica and produce 10 *maunds* of sickle-dressed ruby (S. D. R.) block. The waste is, therefore, nearly 80 per cent. of the mica brought from the mines. To obtain 20 per cent. of cut mica is considered a very good performance; the average of the district varied from 10 to 14 per cent.

The cost of cutting varies. Good cutters or sickle-dressers get as much as nine to ten annas a day while women, working less efficiently, earn three to four annas daily. The average cost at a rate of Re. 0-6-6 works out to about Rs. 4 per *maund* of cut mica obtained.

The sickle-dressed or cut mica was next sized in the Sorting Department to the following scale:—

	Square inches.
Specials	36 to 48
No. 1	24 to 36
No. 2	15 to 24
No. 3	10 to 15
No. 4	6 to 10
No. 5	3 to 6
No. 5½	2½ to 3
No. 6	1 to 2½
No. 7 (*a*)	Less than 1

(*a*) This small size has been utilized comparatively recently.

The following table gives the percentage proportion of the various sizes and qualities obtained by sorting from a month's supply, about 400 *maunds* of cut (S. D. B.) mica.

Quality.	Clear.	Slightly stained.	Fair stained.	Stained.	Waste.
Size.					
Specials	*Nil.*	·005	·010	·005	·100
No. 1	·015	·040	·020	·045	·150
No. 2	·035	·090	·055	·200	·150
No. 3	·080	·160	100	·260	250
No. 4	·380	·800	·480	1·380	·300
No. 5	1·100	2·00	·900	6·000	·650
No 5½	·640	1·300	·020	4·200	·350
No. 6	1·600	4·700	·200	65·500	1 050
Rough films	TOTAL .	4·00		TOTAL WASTE.	3·000
S. D. films	TOTAL .	4·680			

The above figures may therefore be taken as representing a true practical test, so that for every 100 *maunds* of cut unsorted mica only 88 *maunds* were shipped as block (S. D. B.) and some 8⅛ *maunds* were available as films for local sale. This 100 *maunds* of cut mica represents the cutting of 500 *maunds* of rough mica. For every 2 *maunds* of rough mica brought to the godown nearly 1 *maund* is discarded in picking while making up the bundles at the mine ; 750 *maunds* of mined mica, therefore, give 100 *maunds* of cut unsorted mica.

The average mica contents of the workable portions of pegmatites vary greatly—from 3 to 10 per cent. with an average of about 6 per cent. of mica in the total rock excavated ; this works out to less than 1 per cent. of cut or marketable mica from the rock excavated. It would represent a very low grade ore in a metal on mining pro-

position. Unlike the mining of other minerals where every particle of the substance is valuable it is the quality as well as the size of the product mined which is of importance in mica mining. The objective is to produce the largest possible quantity of clear sound mica. It should be free from flaws, cracks or other deleterious defects and in as large pieces as possible. Frequently large "books" of mica are obtained, 1 to 2 feet across, out of which it is perhaps impossible to get a single piece of stained Number 6, owing to the heavily stained, flawed and buckled condition of the plates, or to '*jatai*' by which is meant an interlocking of cleavage plates so that the laminae are stuck together and do not easily come off or split into the clean surfaced thin sheets known as splittings.

From the "sizers," 8 of whom can easily handle 10 *maunds* of cut mica per day, the sized mica is passed to the "graders." 20 graders should deal with 10 *maunds* of sized mica in a day. In the process of separating out the various qualities small cracks or flaws or a film or two have frequently to be removed from the mica plates. There is thus a slight loss in waste and the production of some films. Nine *maunds* of mica worth shipping out of 10 *maunds* was the proportion obtained at Jorasemar with ½ *maund* S. D. films and ½ *maund* of waste.

Formation of Mica Pegmatites.

Holland (*Mem. Geol. Surv. Ind.*, XXXIV, Pt. 2, p. 28) gives the following analyses of Indian mica (Bengal muscovite):—

	(i)	(ii)
SiO_2	45·57	45·71
Al_2O_3	36·72	36·57
Fe_2O_3	0·95	1·19
FeO.	1·28	1·07
MgO	0·38	0·71
CaO	0·21	0·46
K_2O	8·81	9·22
Li_2O	0·19	..
Na_2O	0·62	0·79
F	0·15	0·12
H_2O	5·05	4·83
	99·93	100·67
Sp. Gr.	2·831	2·830

In the majority of cases biotite is also present in association with muscovite-bearing pegmatites. This black mica, however, is not at present utilized; it contains a larger percentage of FeO (16 per cent.) but less H_2O (2 per cent.) than muscovite. The other

associated minerals in a mica-bearing pegmatite are massive granular quartz, coarse aggregates of orthoclase (microcline) felspar, tourmaline, garnet (common, iron), apatite and beryl. In certain rare cases samarskite (Sankara mica mine), pitchblende and monazite have been found (Abraki Pahar, Gaya district). The degree of coarseness in the texture of the pegmatitic constituents indicates quiescent conditions suitable for slow crystallization. The pegmatites stand in striking contrast with the mica-schists and gneisses in which they occur. These rocks are nothing like so coarse textured, their minerals are orientated parallel to the foliation planes and there is abundant evidence of buckling, puckering and crushing. The most careful scrutiny fails to discover any thermal metamorphism at the contact between the pegmatite and the enclosing schists. In some cases the pegmatites are known to form simple lenses in the schists entirely unconnected with any larger mass of pegmatite. Many of the larger pegmatites have been proved to have no connection, other than perhaps the plane of a fault, with any other pegmatite and certainly with no granitic intrusion in the immediate vicinity.

From the above-mentioned facts and data it is evident that in the majority of cases the mica-bearing pegmatites of Jorasemar are not, primarily, of igneous origin. The field evidence points to these lenticular masses of coarse textured granitoid rock as being the re-crystallized products of the mica-schists themselves. The digestion and re-crystallization has, however, been localized to certain particular parts of the metamorphic schists. Careful investigations at Jorasemar appeared to indicate that such recrystallization was best developed in the arches and troughs of folds, in certain fault zones where great crushing took place, or at places where, although no appreciable dynamic forces developed, the static pressures must have been very large. In these circumstances one is led to the possibility that many of the pegmatites of the mica-schists of Bihar and Madras are a large scale representation of the phenomena carried to completion, so evident in the "spotted slates, which so often mark the beginning of change in argillaceous sediments, since in these we see the process arrested at an early stage' (Harker, *op. cit.*, p. lxxi).

Uses of Mica.

It is unnecessary to state in detail the various purposes for which mica is required. Sheet mica has been largely used for stone and furnace windows, for gas lamp chimneys and shades, etc., but the chief use is for electrical

purposes as an insulator, *e.g.*, for separating commutator segments in dynamos, for electric heaters and cookers, in electrical condensers, as washers in sparking plugs, bolts and screws, etc. Formerly size Number 5 was the smallest piece of sheet mica utilized, during the war the utility of smaller sheets (Number 6) was demonstrated, and now size Number 7 is a marketable product. This is largely due to the development of the micanite industry. Micanite is really the built-up sheets of the smallest, thinnest films of mica which are cemented together with shellac dissolved in spirit. The 'made' sheets can be built to any size and thickness. They require to be steamed, pressed and rolled and can in the pressing be moulded to almost any desired shape.

Mention was made of the fact that, although India is the largest producer of mica in the world, practically the whole output is exported. Attention was also drawn to the fact that mica splittings are most cheaply and efficiently made in India. When it is remembered that India holds a monopoly in the production of shellac it is difficult to understand why this country does not hold a predominant position in the manufacture of micanite.

There are numerous published papers which deal with the mica occurrences of India, the British Empire and other countries, and with questions of the marketing of mica generally. Amongst these are the Quinquennial and Annual Reviews of mineral production by the Director of the Geological Survey of India (published in the Records of the Department); Sir Thomas Holland's monograph on Mica (*Mem. Geol. Surv. Ind.*, XXXIV, Pt. 2); T. H. LaTouche's Annotated Index of Indian Minerals of Economic Value; Dr. J. Coggin Brown's compilation of the trade and marketing of mica (Bull. No. 15, Indian Industries and Labour); the brochure on "Mica" issued by the Imperial Mineral Resources Bureau; a pamphlet on "Mica" by Oliver Bowles (Serial No. 2357, Reports of Investigations, Bureau of Mines, Department of the Interior, U. S. A.), etc.

Monazite.

[E. H. Pascoe.]

Uses.

Monazite, an anhydrous phosphate of the rare earths of the cerium group, including especially cerium, lanthanum, neodymium, praseodymium, yttrium and erbium, owes its economic value to the small and variable percentage of

thorium oxide which it contains. Although a market is being developed for some of the other rare earths in special types of arc-lamp electrodes and in the manufacture of special optical glasses, the thoria content is that which gives the mineral its commercial importance. This thoria constitutes the raw material in the preparation of thorium nitrate used in the manufacture of incandescent gas mantles. The percentage of thoria in monazite varies between 1 to 12, but mineral containing less than 3½ per cent. cannot be used remuneratively in the manufacture of thorium nitrate.

The output and value of the past 5 years are shown in the following table :—

Year.	Quantity.	*Value.*
	Tons.	£
1919	2,023·7	*60,712*
1920	1,641	*49,231*
1921	1,260	*30,959*
1922	125	*1,871*
1923	246·3	*3,697*

Sources of world's supply.

Up to the year 1895, the whole of the world's supply of monazite was derived directly or indirectly from the Carolina deposits worked principally by the Welsbach Light Company of New York. In 1895, the sands of the Brazilian coast were first worked by the German Thorium Syndicate and the Austrian Welsbach Company and caused keen competition. The Brazilian deposit being very uniform and considerably richer and more easily available than the Carolina deposits, the American company was forced to suspend operations in May 1910, and practically the whole demand was met by the German and Austrian companies under agreement together. Owing to its occurrence on the sea-shore of Brazil and the very low cost of transport, the German Thorium Syndicate was able to lower the market price of thorium very considerably in spite of the fact that they paid, according to report, about half their profits in royalties to the Government of Brazil. Most of the production from the ore was exported to Germany.

The Brazilian industry, being in the hands of Germans and Austrians, declined as soon as the War broke out, and in 1916 the production was *nil*. The recovery subsequent to that year has been of a spasmodic nature. In 1920, the last year for which figures are available, the Brazilian output amounted to 1,153 metric tons, but in the previous year the amount was only 146 tons. The United States industry still seems to be moribund.

Indian monazite.

Early in the century, monazite was proved by the Imperial Institute to occur in association with the much more valuable thorianite and thorite in Ceylon. The total production of thorium-bearing minerals from that country, however, up to and during 1921 amounted only to some 208 tons. In 1909, monazite-bearing sands were discovered by Mr. C. W. Schomburg of the London Cosmopolitan Mining Syndicate on the Travancore coast. Mr. Tipper, who inspected the deposits, states that the mineral is known with certainty to occur in pegmatite intrusions but is probably mainly derived from the gneisses of the Travancore hills. The mineral occurs in small, round, amber-coloured grains varying from 0·1 to 0·2 millimetre in diameter. Its density is 5·191 and its refractory index is also very high. The best means for identification in the field is a Browning direct-vision spectroscope in which the didymium lines can be observed. The mineral forms one of the constituents of the sands along the sea-shore. In certain places selective action by the waves on the sands has led to the concentration of large quantities of monazite. By mechanical means this sand can be further concentrated.[1] Work was commenced in 1911 by the London Cosmopolitan Mining Company. This was replaced by the Travancore Minerals Company who as a result of the war had been purged of their German interests. Thorium Limited also hold a concession. The whole output, apparently, now goes to the United Kingdom.

Monazite also occurs in the sands to the east of Cape Comorin, in the Tinnevelli District and again near Waltair in Vizagapatam. A crystalline variety containing only 2¼ per cent. of thorium has been found in pegmatites of the Bangalore district, Mysore State.[2]

More recently a large number of beautiful crystals of this mineral have been found with pitchblende and columbite in pegmatites in

[1] *Rec. Geol. Surv. Ind.*, Vol. XLIV, p. 186 (1914).
[2] Mineral Resources of the Mysore State, p. 191.

the Gaya District, Bihar and Orissa.[1] It has also been found in minute quantities in concentrates from Tavoy and Mergui.[2]

Thorianite ?—A black mineral doubtfully identified with thorianite has been discovered at Thadagay Hill, Travancore. The mineral is apparently isometric. The specific gravity is extremely high, namely 10·03. Owing to the paucity of material a partial analysis only could be made, and this gave as the principal constituents, thoria 32·3 per cent. and uranium oxide 40 per cent. The identity with thorianite is very doubtful and it might easily be a variety of uraninite. More is required to be known of this interesting find.

Petroleum.

(E. H. PASCOE.)

Production.

During the previous period reviewed the production of petroleum increased from 259⅓ million gallons in 1914 to 286½ million gallons in 1918. During the past quinquennium there was a rise in 1919 to a production of 305,749,138 gallons, a figure substantially in excess of the previous record figure of 297 million gallons for which the year 1916 was responsible. The figure for 1919 was very nearly again reached in 1921, but the average for the five years was just below 300 million gallons. The total production during the previous quinquennium was some 212 million gallons in excess of the total for 1909-1913; the total for the present period under review shews a further increase but to the extent of 84,300,000 gallons only. The chances are that the next five years will see this increase still further reduced or even replaced by a decrease.

The world's production.

India still contributes a very small proportion of the world's supply and in 1923 turned out only 0·83 per cent. of the world's marketed production. The chief feature of the past five years is the great stride made by Mexico. In 1918, Russia, whose output had hitherto been second only to that from the United States of America, collapsed, and Mexico took her place with a production of 63,800,000 barrels (of 42 United States gallons); in 1919 her production rose to 87 millions and this figure

[1] *Rec. Geol. Surv. Ind.*, Vol. L p. 255 (1919).
[2] *Rec. Geol. Surv. Ind.*, Vol. XLVIII, p. 179 (1917).

was nearly doubled the following year. In 1921 Mexico produced nearly 193,400,000 barrels, or over 25 per cent. of the world's supply; in 1922, however, this dropped to 182¼ million and in 1923 to 149½ million barrels. Since 1920 Russia has shewn a steady improvement, but it is doubtful whether she will ever regain her place as a producer; the fact that the Russian output has never dropped below the third place on the list, in spite of political trouble, is significant of the richness of her fields. Nevertheless, the record output from Russia (over 85 million barrels in 1901) has been more than doubled by Mexico in 1921 and in 1922. It is thought that the total resources of Mexico will eventually prove to be not inferior to those of the United States which country in 1923 supplied over 72½ per cent. of the world's output. Persia now comes fourth on the list. The Dutch East Indies with the support of the young Sarawak field stands fifth, and Roumania whose place, owing to the War, had been usurped by India in 1917, regained her superiority in 1922 and now stands sixth. India's position is now seventh, but there seems every prospect of Peru supplanting her during the next five years.

TABLE 76.—*Production of Petroleum in India during the years 1919 to 1923.*

	QUANTITY.		VALUE.	
	Gallons.	*Metric tons.*(a)	Rs.	£
1919	305,749,138	*1,227,908*	8,40,45,153	7,308,274 (*b*)
1920	293,116,834	*1,177,176*	8,01,78,201	8,017,820 (c)
1921	305,683,227	*1,227,643*	8,46,74,827	5,644,988 (*d*)
1922	298,504,125	*1,198,812*	10,80,37,412	7,202,494 (*d*)
1923	294,215,053	*1,181,587*	10,51,18,737	7,007,915 (*d*)
Average .	*299,453,675*	*1,202,625*	*9,24,10,866*	*7,036,298*

(*a*) The metric ton is assumed to be equivalent to 249 Imperial gallons of crude petroleum, most of which has an average specific gravity of about 0·885.

(*b*) £1 = Rs. 11·5.

(*c*) £1=Rs. 10.

(*d*) £1=Rs. 15.

TABLE 77.—*World's Production of Petroleum in 1918 and 1923.*

	1918.		1923.	
	Metric tons.	*Per cent. of total.*	Metric tons.	*Per cent. of total.*
(1) United States of America.	50,030,040	*70·72*	103,068,675	*72·59*
(2) Mexico . .	8,971,807	*12·70*	21,010,120	*14·80*
(3) Russia . .	3,818,795	*5·40*	5,364,839	*3 78*
(4) Dutch East Indies.	1,796,104	*2·54*	2,108,434	*1·49*
(5) Roumania .	1,227,108	*1·73*	1,525,100	*1·07*
(6) Persia . .	1,212,068	*1·71*	3,514,056	*2·48*
(7) India . .	1,150,944	*1·63*	1,181,587	*0·83*
(8) Galicia . .	847,871	*1·20*	702,811	*0·49*
(9) Peru . .	345,502	*·49*	896,084	*0·63*
(10) Japan . .	344,237	*·48*	238,253	*0·17*
(11) Trinidad . .	292,650	*·41*	433,916	*0·31*
(12) Egypt . .	271,988	*·38*	145,763	*0·10*
(13) Argentina .	174,719	*·25*	456,827	*0·32*
(14) British Borneo .	70,843	*·10*	546,365	*0·39*
(15) France . .	51,024	*·07*	70,703	*0·05*
(16) Venezuela .	46,807	*·07*	534,137	*0·38*
(17) Germany . .	37,952	*·05*	49,759	*0·03*
(18) Other Countries	49,337	*·07*	136,767	*0·09*
TOTAL .	**70,739,796**	*100·00*	**141,984,196**	*100·00*

The world's consumption of petroleum has been increasing by leaps and bounds and should aviation ever become the craze that motoring has, the exhaustion of the supplies of natural petroleum is well within sight. Attention is being directed more and more towards oil shale and there is little doubt that this will be the immediate remedy for the coming shortage. The enormous size of the oil shale deposits in the world is insufficiently realised, and the amount of crude oil ultimately obtainable therefrom is probably many times the ultimate total supplies of the natural fluid [1]; the United States is again the favoured country in this respect. The final remedy for the exhaustion of mineral oil will consist of oils and alcohols derived from vegetable or possibly animal sources. Investigations in this direction are proceeding in many places, especially in France, and a rise in the price of petroleum commodities may make such sources economically utilizable before the mineral deposits shew any real proximity to exhaustion.

[1] Pascoe; Presidential address, Mining and Geological Inst. of India, *Trans.*, Vol. XIX, pp. 19-50 (1924).

Foreign mineral oil has to some extent been displaced by the domestic products, but consumption is still on the increase in India and there persists a large market in India and Burma for foreign oil, which has to pay an import duty. In the case of motor spirit and kerosene this duty up to the 1st March 1922 was 1½ annas per gallon, but since that date it has been increased to 2½ annas. Jute-batching oil, lubricating oil and fuel oil of a flash-point of over 150°F., pay an import duty of 7½ per cent. *ad valorem.* The average annual imports of foreign mineral oils during the period 1913-14 to 1917-18 amounted to about 89¾ million gallons, valued at nearly 2¾ millions sterling. while for the five financial years 1918-19 to 1922-23 the average annual import shows an increase of about 27½ million gallons, the average annual value being Rs. 7,07,21,197 (see Table 78). The largest import occurred in 1919-20 when nearly 141½ million gallons of foreign oil came into India, while the lowest figure, under 60½ million gallons, was reached in 1918-19, following a minimum import in 1917-18 of the preceding quinquennium. The chief feature of the period under review is the great increase in the contributions received from Persia. In the five-year period 1908-1909—1912-13 the United States supplied 53·2 per cent. of the imports, and during 1913-14 to 1917-18, 54·8 per cent. The United States maintained its place as the predominant source of foreign supplies supplying 40·0 per cent. of the total imported into India, but during the two years 1921-22 and 1922-23 this predominance was seriously challenged by Persia, and actually usurped by that country to the extent of 256,000 gallons in 1918-19, a year of abnormally low imports. The expansion of the Persian output was foretold in the previous quinquennial review. The proportion supplied by Borneo has decreased from 23·3 per cent. to 19·2 per cent. but the average annual amount contributed increased by over 1½ million gallons. No imports from Russia were recorded during the period, with the exception of 819,407 gallons in 1920-21.

Imports of Kerosene.

The values of the imported mineral oil during the period under review are shown in Table 79; the average annual value was Rs. 7,07,21,197 as compared with an average of Rs. 4,12,34,850 for the previous period; the average value per gallon, however, sank from As. 7·35 to As. 7·09.

Value of Imports.

The annual exports of oil shew a slight decrease compared with figures for the previous quinquennium; the average exports of paraffin wax increased by 108,000 cwts. (see Table 80)

Exports.

TABLE 78.—*Origin of Foreign Mineral Oil imported into India during the years 1918-19 to 1922-23.*

Countries.	1918-19.		1919-20.		1920-21.		1921-22.		1922-23.		AVERAGE.	
	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*
Borneo . .	7,769,627	*12 9*	40,717,837	*28 2*	33,782,573	*27 0*	13,489,686	*10·9*	16,632,502	*12·5*	22,478,445	*19·2*
Persia . .	23,519,852	*38 9*	35,761,803	*24 7*	28,440,676	*22 7*	51,385,505	*41·8*	50,917,216	*38 3*	38,005,010	*32·4*
United States of America.	23,263,489	*38 5*	57,318,335	*39 7*	50,074,194	*39 9*	51,623,204	*42·0*	52,221,404	*39 3*	46,900,125	*40·0*
Other Countries	5,888,182	*9·7*	10,697,602	*7 4*	13,097,820	*10 4*	6,472 026	*5 3*	13,132 483	*9 9*	9,857,623	*8·4*
TOTAL	**60,441,150**	*100 0*	**144,495,577**	*100·0*	**125 395,263**	*100 0*	**122,970,421**	*100 0*	**132,903,605**	*100 0*	**117,241,203**	*100·0*
Value . .	Rs. 3,61,31,850	..	Rs. 9 26,48,150	..	Rs. 8,34,09,200	..	Rs. 7,33,93,668	..	Rs. 6,80,23,116	..	Rs. 7,07,21,197	..

TABLE 79.—*Annual value of Mineral Oil imported during the years 1918-19 to 1922-23.*

Countries.	1918-19.	1919-20.	1920-21.	1921-22.	1922-23.	AVERAGE.	*Average value per gallon.*
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	*As.*
Borneo . .	40,32,495	1,90,36,660	1,48,96,590	81,65,145	76,63,093	1,07,58,797	*7·65*
Persia . .	57,56,070	1,46,98,990	67,14,340	1,08,57,952	1,04,26,002	96,90,671	*4·08*
United States of America.	2,19,73,170	5,23,73,950	5,29,97,850	4,86,84,273	4,12,14,869	4,34,48,822	*14·82*
Other Countries	43,70,115	65,38,550	88,00,420	56,86,298	87,19,152	68,22,907	*11·07*
TOTAL .	**3,61,31.850**	**9.26.48.150**	**8,34,09,200**	**7,33.93.668**	**6.80.23.116**	**7,07,21,197**	*9.66*

TABLE 80.—*Exports of Mineral Oil and Paraffin Wax during the years 1919 to 1923.*

Year.	Mineral oil.	Paraffin wax.
	Gallons.	Cwts.
1919	35,566,743	532,480
1920	22,063,892	461,860
1921	22,085,017	621,160
1922	19,918,232	552,720
1923	19,029,224	491,280
Average .	*23,732,622*	*531,900*

Occurrence of Indian petroleum.

The petroleum resources of the Indian Empire are confined to the sites of three ancient gulfs:

(1) The Burmese gulf, covering what is now the basins of the lower Irrawadi and its main tributary the Chindwin and opening southward into the Bay of Bengal.

(2) The Assam gulf occupying the middle portion of the present Brahmaputra and debouching into the Bay of Bengal *viâ* the modern Meghna basin; and

(3) The Punjab-Baluchistan gulf extending along the base of the Himalayas northwestward from a point opposite Naini Tal, and curving round through the Potwar plateau south-south-westwards through what are now the Baluchistan hill ranges, to the Arabian sea.

In all three areas the oil is associated with Tertiary strata, and has had probably similar conditions of origin in all cases. In Burma it is known to occur in beds of Nummulitic age, but by far the greater number of seepages and all the fields of importance are in the next highest geological series, to which there is every reason to suppose the oil is indigenous. In Assam oil is found in a similar series. In the Punjab on the other hand it is the Nummulitic which is the predominant oil-yielding series, and although the only supplies which have so far proved of economic importance are found in the series above, there is good reason to suppose that the oil has migrated up from the Nummulitic below. Whether in Burma, Assam or North-West India, the occurrences of petroleum are always connected with an anticlinal structure. In the Yenangyaung field, the best known field of Burma, conditions have been ideal. The area lies on a N.N.W.-S.S.E. flat anticline, the axis of which by variation in pitch has produced a flat dome in the Kodaung tract. The rocks in this dome include several porous sands at various depths, each covered by an impervious clay-bed, which has helped to retain the oil until the impervious layers are pierced by artificial wells.[1]

The provincial production of petroleum in India is shown in Table 81.

TABLE 81.—*Provincial Production of Petroleum during the years 1919 to 1923.*

Provinces.	1919.	1920.	1921.	1922.	1923.
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
Burma . .	293,846,129	279,707,170	296,092,057	281,759,169	271,405,947
Assam . .	11,788,679	13,358,172	9,530,934	9,382,641	11,004,096
Punjab . .	114,330	51,492	60,236	7,362,315	11,805,010
TOTAL, Gallons	**305,749,138**	**293,116,834**	**305,683,227**	**298,504,125**	**294,215,053**
Total, Metric Tons	*1,227,908*	*1,177,176*	*1,227,643*	*1,198,812*	*1,181,587*

[1] E. H Pascoe: The Oil-fields of Burma, *Mem., Geol. Surv., Ind.*, Vol. XL, pt. 1 (1912).

A similar area to that of Yenangyaung with a structure as favourable, is now being exploited at Khaur in the North Punjab. In many parts of the Punjab, however, and in the Baluchistan area the strata have been too tightly folded, or the rock-folds have been too deeply truncated by agents of denudation or have been dislocated by earth-movements. and much of the original stores of oil have disappeared; oil-springs are common enough, but many of them seem to be mere "shows" not connected with reservoirs that can be tapped by artificial means.[1] In the Punjab, oil-springs have been known for many years to exist in the Rawalpindi district and further to the south-west, but the total output of the province up to 1915 was negligible. From that year onwards, however, owing to the development of the Khaur field in the Attock district, the figure, though small at first, began to assume serious proportions, and will almost certainly expand still more in the near future. In 1918 it rose to over $\frac{3}{4}$ million gallons, but no really big stride was made till 1922 when over $7\frac{1}{3}$ million gallons were produced; in 1923 this output was increased to over $11\frac{3}{4}$ million gallons. The test wells in the Dhulian and Gabhir areas, sunk by the Attock Oil Company, have been abandoned at 2,800 feet and 1,970 feet respectively; a small showing of oil was encountered in the latter. A new test has been started at Dhulian and the advisability of further experiment in the Gabhir area is under consideration After several years of patient and expensive test drilling in the areas of Khaipa and Khabakki in the Punjab, the Burmah Oil Company have recently decided that there are no prospects of obtaining oil therefrom in commercial volume, and that the areas are to be abandoned.

Punjab and Baluchistan.

The oil industry of the Punjab entered on a new phase with the completion at Rawalpindi, and the opening in February 1922, of the refinery erected by the Attock Oil Company to deal with the production from the Khaur field. The refinery has a daily capacity of 65,000 gallons of crude oil, but the throughput has not yet reached the maximum. For an account of the occurrence of oil in Baluchistan, reference should be made to the Quinquennial Review for the years 1898-1903 (Records, Vol. XXXII, p. 74).

[1] E. H. Pascoe: Petroleum in the Punjab and N W. Frontier, *Mem., Geol. Surv.* Vol. XL, pt. 3 (1920).

Assam.

Oil-springs are known in various parts of Assam, the most prominent being those appearing in the coal-bearing series in North-East Assam, especially in the Lakhimpur district,[1] and those at the southern foot of the Khasi and Jaintia Hills. Marketable oil comes from the Lakhimpur district, where systematic drilling has been conducted at Digboi during the past thirty years by the Assam Oil Company, Limited. The output of the Digboi area was maintained during the first four years—1919-1922—at a steady uniform rate of a little over 5 million gallons annually, but in 1923 rose to nearly 7½ million gallons. The Badarpur field in Cachar produced over 8 million gallons in 1920, but has steadily declined since. The oil in this field is of poor quality and is unfortunately accompanied by large quantities of water. It is, moreover, anticipated that no considerable nor very profitable additional production is to be expected.

The principal products marketed from the Digboi area are petrol, jute-batching oil, lubricating oils, paraffin wax and a comparatively low grade of kerosene suitable for bazar consumption. The wax, sold as such or in the form of candles, appears to be of excellent quality with a melting point of 135°F. and over.

Table 82 shows the amounts of the various products turned out during the past five years.

The average number of persons employed daily on the Digboi area during the period under review was 1,057.

TABLE 82.—*Output of the Digboi Oil Refineries in the years 1919 to 1923.*

——	1919.	1920.	1921.	1922.	1923.
Kerosene (*a*) . . .	2,715,685	2,548,379	2,080,364	2,259,046	3,196,432
Batching and lubricating oil (*a*).	427,745	458,947	363,659	381,638	408,146
Spirit (*a*)	415,155	471,154	520,651	661,250	1,100,860
Wax and candles (*b*). .	1,788,022	1,713,558	2,018,408	2,423,846	3,202,968
Sundry oils (*a*). . .	348,227	361,402	306,362	294,363	337,138

(*a*) Imperial gallons.
(*b*) Lbs.

[1] E. H. Pascoe : The Petroleum Occurrences of Assam, *Mem., Geol. Surv., Ind.*, Vol. XL, pt. 2 (1914).

The most productive oilfields of Burma are those on the eastern side of the Arakan Yoma forming a belt stretching along the valleys of the Chindwin and the lower half of the Irrawadi, and including the oil-fields of the Upper Chindwin, Yenangyat in the Pakokku district, Singu in Myingyan, Yenangyaung in Magwe, Thayetmyo and Minbu. It has been shown that this belt coincides with the site of a gulf which existed in the Pegu epoch (approximately Oligocene and Miocene), and which gave place to a river, the forerunner of the present Chindwin-Irrawadi.[1] The production of the Burmese oilfields for the years 1919 to 1923 is shown in Table 83.

Burma.

Yenangyaung, the oldest and best known of the fields, still holds an easy lead as a producer. Of the total 1½ square miles of petroliferous territory, all that outside the two native 'reserves' of Twingon and Beme is held under lease by the Burma Oil Company, the pioneers of this field. It is within the two small reserved tracts covering jointly some 450 acres, and especially within the Twingon Reserve, that competition has been so keen as to threaten injury to the oil-sands by water liberated from water-sands, and danger of fire in the midst of a congested forest of greasy wooden derricks covering highly productive flowing wells emitting immense quantities of inflammable gas. The appointment of a Warden, who is assisted by an Advisory Board composed of representatives of the companies engaged in exploiting the field, resulted in systematic measures for the protection of the sands, and has undoubtedly done much to prolong the life of the field. Fears have been expressed that excessive exploitation was leading to premature exhaustion; but although the yield from the upper sands is now very small, lower horizons still continue to be tapped by deep wells, which now reach depths of 3,000 feet and over, and a fairly steady output in the neighbourhood of 180 million gallons per annum is maintained. The average annual output was, however, some 9½ million gallons short of that obtained during the previous five years. Wells tapping the deepest sands show a tendency towards a swifter decline in yields; this is perhaps due to the natural shrinking and tightening of the anticlinal area as deeper and deeper horizons are reached. The total depth to which the petroliferous horizons extend is still an unanswered question. The shallow oil-sands which were shut

Yenangyaung.

[1] *Mem., Geol. Surv., Ind.*, Vol. XL, p. 251.

off during the competitive rush for the richer deep sands, are now being to some extent utilized, and several remunerative wells are being worked at depths a little above or below 400 feet. During the period under review another feature in this field has been the electrification of the pumping plant which has been applied to a large number of the wells.

TABLE 83.—*Production of the Burma Oil-fields during the years 1919 to 1923.*

Oil-fields or District.	1919.	1920.	1921.	1922.	1923.	*Average.*
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
Akyab	10,718	9,770	9,780	8,886	8,628	*9,556*
Kyaukpyu	31,266	30,075	27,869	16,211	16,721	*24,428*
Minbu	4,423,361	3,835,198	3,706,831	3,940,416	3,915,140	*3,964,159*
Singu	93,626,506	95,256,753	104,167,749	92,107,998	87,476,474	*94,527,076*
Thayetmyo	113,784	91,329	66,372	2,319,835	1,818,584	*881,981*
Upper Chindwin	1,085,030	1,022,766	1,182,782	1,210,914	1,311,644	*1,162,627*
Yenangyat	4,123,387	3,176,231	2,510,533	2,413,416	1,700,035	*2,784,720*
Yenangyaung	190,432,077	176,285,048	184,420,141	179,741,493	175,158,721	*181,207,496*
TOTAL, Gallons	**293,846,129**	**279,707,170**	**296,092,057**	**281,759,169**	**271,405,947**	*284,562,093*
Total, metric tons	*1,180,105*	*1,123,322*	*11,89,124*	*1,131,563*	*1,089,981*	*1,142,819*

The output of the Yenangyat field, which was never a very rich one, showed a serious decline between 1905 and 1910. During the five years 1909-1913, the average annual production amounted to little more than 5 million gallons which was maintained during the period 1914-1918. During the five years 1919-1923 this figure fell to a little over $2\frac{3}{4}$ million gallons; the production in 1923 was as low as 1,700,000 gallons. The Yenangyat field is rapidly dying; much of it is in fact already dead.

Yenangyat.

Although inferior to Yenangyaung, Singu is a promising field, and was for many years treated as a reserve by the Burma Oil Company from which to make good any decline in other areas. It is now being steadily and scientifically developed, the annual average production showing an increase of over $23\frac{1}{2}$ per cent. in comparison with the preceding quinquennium, but not yet amounting to much more than half that from Yenangyaung. Oil in remunerative quantity was struck in 1920 by the Indo-Burma Petroleum Company near Lanywa in the south of the Yenangyat area. The interest of this discovery lies in the fact that this oil properly belongs to the Singu dome-centre and that the river Irrawadi between Lanywa and Kyauk-ywa probably

Singu.

covers workable oil deposits; the reclamation of part of this river area is under consideration.

Minbu.

In the year 1910 Minbu began to produce for the first time. In 1918 the production rose to 4·8 million gallons, but the average during the past five years is under 4 million gallons. As foretold, this field has proved a very narrow one, with rapidly diminishing supplies.[1]

Chindwin.

The Chindwin field under the Indo-Burma Petroleum Company began to produce in 1918, yielding nearly half-a-million gallons. In spite of a very great deal of laborious prospecting, this is the only additional area in Burma to those described in 1912 in the Geological Survey Memoir, which has ever got beyond the testing stage, but time alone will show whether it will make any serious difference to the oil supply of Burma; between 1919 and 1923 it has produced steadily over one million gallons a year. Yenangyaung, Singu, Yenangyat and Minbu are the four areas which alone have so far proved of real economic importance.

Arakan Coast.

Besides the Upper Burma oil-fields, the islands off the Arakan coast, noted for their mud vulcanoes, have also been known for many years to contain oil deposits of uncertain value. The chief operations have been carried on in the Eastern Baronga Island near Akyab and on Ramri Island in the Kyaukpyu district. Folding and denudation in these regions have been too severe to warrant the expectation of oil in much quantity. The output both from the Kyaukpyu wells and from those in the Akyab area, declined during the past five years.

Ruby, Sapphire, and Spinel.

[E. H. PASCOE.]

Production.

During the period covered by this review, the whole of the output of ruby, sapphire and spinel in the Indian Empire was derived from Upper Burma. Table 84 shows the annual output figures for Burma during the period under review, the average annual value being £60,660.

[1] *Mem., Geol. Surv., Ind.*, XL, p. 164.

TABLE 84.—*Production of Ruby, Sapphire and Spinel in Burma during the period 1919 to 1923.*

Years.	Quantity.	Value.	
	Carats.	Rs.	£
1919	158,577	*10,80,870*	(*a*) 93,989
1920	155,604	*6,19,820*	(*b*) 61,982
1921	193,915	*7,52,459*	(*c*) 50,164
1922	231,160	*7,27,312*	(*c*) 48,487
1923	187,010	*7,30,188*	(*c*) 48,679
Average .	*185,253*	*7,82,130*	*60,660*

(*a*) £1=Rs. 11·5. (*b*) £1=Rs. 10. (*c*) £1=Rs. 15.

Burma.

The prosperous condition in the early years of the century of the ruby mining industry as conducted by the Burma Ruby Mines, Limited, in the Mogok area, continued until towards the end of 1907, when the demand for rubies suddenly fell away and prices declined, owing to the world-wide commercial depression that then set in. The slump continued in subsequent years and the value of the production, of which the annual average was over £84,000 during the period 1904-08, fell to £63,272 between 1909-13 and to £41,817 during 1914-18; between 1919 and 1923 it rose to £60,660. The rubies are derived from crystalline limestones which stretch westwards from Mogok as far as the Irrawadi, but the Company obtain all their output from the alluvial detritus of the Mogok valley. At the mouth of the valley a waterfall supplies electric power.

The Burma Ruby Mines, Limited, was granted a new lease for 28 years with effect from the 30th April 1904, for the collection of precious stones in the townships of Mogok, Kyatpyin and Katha in the Ruby Mines district. The Company was required by the lease to pay an annual rent of Rs. 2,00,000 (£13,333), *plus* 30 per cent. of the net profits made each year, this being a continuance of the arrangement previously in force. In consequence of the

slump the Company was unable to pay dividends for the years 1908-10, but matters improved slightly during 1911 and a dividend at the rate of $4\frac{1}{8}$ per cent. was paid for the year ending February 29th, 1912, and a similar dividend for the year ending February 28th, 1913. The year 1913 was a bad one and resulted in a deficit of over £9,000 for the twelve months ending February 28th, 1914. Owing to this succession of poor years, the Company was compelled to approach the Burma Government with a view to the remission of arrears of rent and other charges. These amounted in 1909 to nearly £24,000; the Government agreed to the postponement of payment of this sum and arranged that the Company should make over the royalties collected from the local native ruby-miners less a fee of 10 per cent. on account of charges for collecting. In 1911, the Company proceeded to develop new ground in the neighbouring valleys of Kathé and Bernardmyo and, on the understanding that £20,000 would be spent on such development, the Government agreed, with the sanction of the Secretary of State, to remit the Company's debts on account of arrears until such time as the profit should exceed 10 per cent. on the present paid-up capital. At the end of 1913, the proceeds of local sales fell off to such an extent that further concessions by the Government were found necessary early in 1914.

Labour. The following are the labour statistics for the ruby mines under the Mines Act :—

Year.	Average number of persons employed daily.
1919	1,319
1920	1,207
1921	1,242
1922	1,254
1923	1,285

The number of deaths during the period was 2 as in the previous quinquennium, giving an average death rate of 0·32 per 1,000 persons employed.

In addition large numbers of persons are engaged in working on their own account under licenses issued by the Burma Ruby Mines, Limited.

Rubies are known to occur at Naniazeik in the Myitkyina district near the jadeite tract,[1] but no output has been reported for the period under review. Ruby-bearing ground was also discovered during the year 1913 in Momeik State and royalties amounting to Rs. 1,740 were collected by the Local Government from the native miners. Sapphires are found accompanying the rubies in the Ruby Mines of Upper Burma and are undoubtedly of the same origin.

Kashmir.

The sapphires of Kashmir seem to have been first discovered in 1881 or early in 1882, when a landslip disclosed the sapphire-bearing rocks. These were found to be intrusive pegmatities containing tourmaline, garnet, kyanite and euclase in addition to the sapphires. The actual locality is a valley near Sumjam in Padar, Zanskar, at an elevation of about 14,000 feet; here the gem has been found both *in situ* in a felspathic igneous rock in a cliff 1,600 feet above the valley, and in the débris in the valley itself. For some years the Kashmir Darbar derived a considerable revenue from the sapphire mines, which were then left unworked for some years on the supposition that they had become exhausted. In 1906 the Kashmir Mineral Company, Limited, started work under license from the Darbar, and obtained a considerable return of valuable stones. One stone obtained in 1907 was sold for £2,000. Subsequent results, however, were discouraging and no serious work has been done during the past fifteen years. Owing to the high altitude of the sapphire locality, the ground is under snow and inaccessible for the greater part of the year, work being possible only during the months of July, August and September.

Salt.

[W. A. K. Christie.]

Production.

The average annual production of salt in India during the five years 1919 to 1923 was 1,580,272 statute tons (see table 86) exclusive of that from Aden, which averaged 167,727 tons per annum The average annual produc-

[1] *Rec., Geol. Surv., Ind.*, XXXVI, p. 164 (1907).

tion shows a considerable rise of 135,000 tons over that of the previous quinquennium and of 228,000 tons over that of 1909 to 1913. This is largely the result of permanent measures for increased production taken in the later years of the war when imports were restricted. The aftermath of the war is also apparent in the fluctuating figures for imports which, however, in the later years of the quinquennium were approaching those for pre-war years. The salt manufactured in the country and imported by sea amounted annually to over 2 million tons. The consumption thus amounted to about 14⅓ lbs. per head of the population. The duty of one rupee four annas a *maund* (82 lbs.) remained in force up to the 1st March 1923, from which date it was raised to two rupees eight annas. Indents for salt from Government sources were heavily affected when the duty was raised, merchants having accumulated large stocks against the possibility of an increase and believing that the opposition to it might result in at least a partial reduction.

TABLE 85.—*Production of Salt in India (excluding Aden).*

Year.	Statute.	Metric.
	Tons.	Tons.
1919	1,763,577	1,791,794·2
1920	1,448,948·6	1,472,131·7
1921	1,377,095	1,399,128·5
1922	1,449,865·2	1,473,063
1923	1,611,873·9	1,637,664
Average .	1,530,271·9	1,554,756·3

Sources of Indian Salt.

The salt produced in India is obtained from three principal sources, *viz.*, from sea water, from sub-soil water and lakes of internal drainage, and from rock-salt beds. The largest amount—about 60 per cent.—is derived from the first source, chiefly in Bombay and Madras, while the rock-salt beds of the Salt Range of Kohat and of Mandi State provide about one-tenth of the Indian output.

Provincial production.

Table 86 shows the provincial production for the five years 1919 to 1923.

TABLE 86.—*Provincial production of Salt during the years 1919 to 1923.*

Province.	1919.	1920.	1921.	1922.	1923.	Average.
	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.
Aden	127,561	181,174	156,584	204,033	169,282	167,727
Bengal. . . .	10	30	35	3	..	(*b*) 15
Bombay and Sind .	630,481	473,376	514,379	450,558	613,150	536,389
Burma. . . .	74,492	65,107	43,028	33,535	33,622	49,957
Central India . .	..	11·6	1	9 7	9·3	(*b*) 6
Gwalior State (*a*) . .	149	232	159	210	22	154
Kashmir . . .	..	..	..	..	0·6	(*c*)
Madras . . .	552,308	453,517	446,113	465,929	485,569	480,693
Northern India (including Rajputana).	505,864	456,538	373,184	199, 386	479,295	462,853
Rajputana (Indian States)	273	107	196	234 5	206	204
Total Statute Tons .	1,891,138	1,630,122·6	1,533,679	1,653,898 2	1,781,155·9	1,697,998
Total Metric Tons .	1,921,396·2	1,656,204·5	1,558,217·8	1,680,360·5	1,809,654·3	1,725,166·7

(*a*) Relating to official years.
(*b*) Average of 5 years.
(*c*) Not taken into average.

The returns for provinc'al production show a small decrease in the amount of Aden salt from 178,221 tons, the average for the years 1914 to 1918, to 167,727 tons a year in the quinquennial per'od 1919-23; there was a considerable increase in Bombay from an average of 487,139 tons to 536,389 tons per annum; in Madras from 423,850 to 480 693 tons; in the north Indian 'akes and mines from 444,747 to 462,853 tons, and in Burma from 39,059 tons to 49,957 tons per annum. The average annual total of sal production has thus risen from 1,573,323 tons for 1914-18 to 1,697,998 tons for 1919-23.

Bombay Salt.

Bombay, as befor:, is the largest producer. Most of the salt is obtained from sea water. The factories at Dharasna and Charwada on the south of the Gujarat coast near Buisar are both Government property and worked departmentally. The other sea salt works, with three exceptions, are grouped within a radius of 30 miles of Bombay City. Those which are Govern-

ment property are leased to private individuals for working; the others are owned as well as worked privately. A considerable proportion of the Bombay salt product on is Baragra or Rann salt, made from brine wells on the edge of the Lesser Rann of Cutch in the salt works at Kharagoda and Udu. These are Government property and worked departmentally. The brine is probably derived directly from sea water. A subsidiary industry has been started at Kharagoda for the recovery of magnesium chloride from the bitterns from salt manufacture and the production of refined table salt. Towards the close of the period under review the Government of Bombay commenced a boring survey of the salt resources of the Lesser Rann with a view to its further development.

Madras Salt.

In the Madras Presidency, with the exception of small quantities collected in the Masulipatam area, all the salt is made from sea water in a large number of factories scattered along the coast. The Madras Board of Revenue has lately been endeavouring to concentrate the manufacture of salt in a few large factories or groups of factories with a view to economy in working.

Burma Salt.

In Upper Burma salt is obtained from sub-soil brines in the districts of Sagaing, Shwebo, Myingyan, Yamethin, Lower Chindwin, Minbu, Meiktila, and in the Hsipaw State. It is often difficult in some of the districts in the "dry zone" of Upper Burma to obtain deep well water that is not noticeably saline. A spec a account of the brine wells being worked near Bawgyo in the Hsipaw State has been published by T. H. D. LaTouche.[1] The only well being worke l at the time was 45 feet deep, and the crude brine included 25·58 per cent. of dissolved salts, which were composed of about 60 per cent. of sodium chloride and 36 per cent. of the sulphate, with small quantitie of other salts.

Sub-soil and lake-brine.

The most important of the areas worked for sub-soil and lake-brine is the desert region of Rajputana. The whole country is impregnated with sal from the coast of Cutch and Sind north and north-eastwards to the borders of Delhi district and Bahawalpur State. In many areas of internal drainage there are temporary salt-lakes which are utilised as at Sambhar and Didwana; while in other places

[1] *Rec., Geol. Surv., Ind.*, XXXV, p. 97 (1907).

sub-soil brine is raised, as at Pachbadra. Most of the salt in this region appears to be brought in as fine dust by the strong winds which blow from the south-west and south-south-west during the hot weather. These winds blow across the salt-incrusted Rann of Cutch, and carry away the finely-powdered salt in large quantities into the heart of Rajputana, where it becomes fixed when the following monsoon brings rain enough to wash the salt into the small lakes in areas of internal drainage.[1]

Sambhar Lake.

Sambhar, the largest of the Rajputana salt-lakes, covers an area of about 90 square miles at its highest level, but dwindles, generally, to a small central puddle by March or April. It has been shown by careful sampling at regular intervals that the mud forming the bed of the lake contains on an average 5·21 per cent. of sodium chloride down to a depth of at least 12 feet, and the amount stored in these higher layers of salt cannot thus be less than about 54 million tons.

Considerable improvements have been effected at the Lake during the period under review. A substantial dam has been built across the Lake between Gudha and Japog, forming at the Sambhar end a reservoir of about five square miles. Manufacture has thus been rendered much less dependent on a capricious rainfall, for into this reservoir in a year of scanty rains sufficient brine for a normal salt crop can be pumped from the main body of the Lake before evaporation causes recession too far from the shores. An electric power station has been erected at Sambhar with high tension transmission lines to transformers and powerful pumps at the dam and elsewhere. More complete arrangements have been made for isolating the mother liquors after the salt crop has been extracted. The transport system, too, has been reorganised and salt on extraction is now railed direct to a large central store at Sambhar with considerable saving of labour. An investigation into the alleged depreciation of the quality of the brine was conducted by the Department of Northern India Salt Revenue and the Geological Survey for the years 1908 to 1917. On account of the war the results of this were not available for inclusion in the last quinquennial review. From the point of view of the salt manu

[1] T. H. Holland and W. A. K. Christie, *Rec., Geol. Surv., Ind.*, XXXVIII, pp. 151—186 (1909).

facturer the brine has undergone a small but appreciable deterioration during the ten year period, the sulphate and carbonate of soda content having increased; but the depreciation is not at all serious and gives no cause for anxiety.

Distribution of Sambhar Salt.

Table 87 shows the average annual distribution of Sambhar Salt during the five years 1918-19 to 1922-23 with the corresponding figures for the previous quinquennium. The increased production was absorbed by the United Provinces. It may be noted that Sambhar still retains its footing in the Bihar and Orissa market, which before the war absorbed only a fraction of a per cent. of the total.

Distribution of Pachbadra Salt.

The average annual despatch of salt from Pachbadra during the years 1918-19 to 1922-23 amounted to 25,544 tons against 33,679 tons in the years 1913-14 to 1917-18. Of this amount 11,772 tons, or 46·1 per cent. remained in Rajputana; 6,096 tons, or 23·9 per cent. went to Central India, 3,691 tons, or 14·4 per cent. to the Central Provinces, and 3,676 tons or 14·4 per cent. to the United Provinces.

TABLE 87.—*Average annual distribution of Sambhar Salt.*

—	1913-14 TO 1917-18.		1918-19 TO 1922-23.	
	Quantity.	*Per cent of total.*	Quantity.	*Per cent of total.*
	Tons.		Tons.	
United Provinces	124,570	*60·7*	157,574	*68·4*
Rajputana	29,367	*14·3*	28,044	*12·2*
Central India	18,993	*9·3*	15,471	*6·7*
Punjab including Feudatory States and Delhi.	8,509	*4·1*	8,640	*3·7*
Central Provinces	4,666	*2·3*	4,081	*1·8*
Bihar and Orissa	19,164	*9·3*	16,338	*7·1*
Bengal	..	..	118	*0·1*
Bombay	..	..	74	..
Average Total	**205,269**	***100·0***	**230,340**	***100·0***

Production of rock-salt.

The average annual output of rock-salt is practically the same for 1919-23 (1780,38 tons per annum) as for 1914-18 (177,611 tons); this represents 10·5 per cent. of the total production of India, excluding Aden. The details are shown in Table 88.

A general account of the occurrences of rock-salt in the Punjab and North-West Frontier Province will be found in a previous Review (*Records*, Vol. XXXII, pages 83, 84) and in a paper by the writer published in the *Records* (Vol. XLIV, pages 241—264). The mines of the Salt Range are responsible for by far the largest share of the output. In these many improvements have been effected during the five years. Into the Mayo Salt Mine hill at Khewra a low-level tunnel over a mile in length, terminating in the bottom salt seam, has been completed. A gravity incline connects this with the two higher main seams and the potential output from the mine has been greatly increased. Air compressors direct coupled to oil engines in the mine have largely done away with hand drilling. Similar improvements have been made at the smaller mine at Warcha and a new section has been opened there in a good seam of salt capable of producing 44,000 tons annually. At Kalabagh, on the west bank of the Indus, quarrying has been replaced by mining with considerable economy.

TABLE 88.—*Production of Rock-salt during the period 1919-23 compared with the period 1914-18.*

Year.	Salt Range, Punjab.	Kohat, North-West Frontier.	Mandi State.	Total.	*Percentage of total salt production of India.*
	Tons.	Tons.	Tons.	Tons.	
1919	174,598	25,931	4,800	205,329	*10·9*
1920	181,480	23,142	5,217	209,839	*12·9*
1921	123,084	19,635	5,319	148,038	*9·7*
1922	183,533	18,904	4,875	207,312	*12·5*
1923	100,932	14,640	4,101	119,673	*6·7*
Average for 1919-23 . .	**152,725**	**20,451**	**4,862**	**178,038**	***10·5***
Per cent. of average total 1919-23.	85·8	11·5	2·7	..	..
Average for 1914-18 . .	*152,500*	*20,930*	*4,181*	*177,611*	*11·4*
Per cent. of average total for 1914-18.	85·9	11·7	2·4	..	..

There was a considerable increase, amounting to about 15 per cent., in the imports of foreign salt, mainly due to enhanced quantities from Aden and Germany. Great Britain showed an appreciable recovery, but the figures are still far behind those of pre-war years. Imports from Egypt, Arabia and Spain declined. Most of the salt imported is landed at Calcutta, the next largest importer being the province of Burma, which, however, only takes about 54,000 tons a year.

Imports and origin of foreign salt.

TABLE 89.—*Average annual Imports of Salt during 1919-20 to 1923-24 and during 1914-15 to 1918-19.*

—	1914-15 TO 1918-19.		1919-20 TO 1923-24.	
	Quantity.	Per cent. of total.	Quantity.	Per cent. of total.
	Tons.		Tons.	
United Kingdom	78,108	*17·6*	84,981	*16·6*
Aden	113,470	*25·6*	165,027	*32·3*
Spain	59,996	*13·5*	53,880	*10·5*
Arabia	6,437	*1·4*	..	..
Egypt	134,213	*30·3*	104,653	*20·5*
Germany	6,198	*1·4*	44,674	*8·7*
Italian East Africa	45,087	*10·2*	57,092	*11·2*
Other Countries	66	..	1,011	*0·2*
Average annual total	**443,575**	***100·0***	**511,318**	***100·0***

Potash salts are found associated with rock salt in the Salt Range [1] and from 1919 until the closing down of the Nurpur mine in 1921 were worked to a small extent. About 240 tons were sent to Calcutta for fertiliser use.

Potash salts.

[1] *Cf.* W. A. K. Christie, *Rec. Geol. Surv. Ind.*, XLIV, p. 243 (1914); M. Stuart, *ibid*, L. p. 55 (1919); and the previous Quinquennial Review, *ibid.*, LII, p. 227 (1921).

Saltpetre.

[W. A. K. Christie.]

Conditions essential for the formation of saltpetre.

For the formation of saltpetre in a soil the necessary conditions are (1) supplies of nitrogenous organic matter, (2) climatic conditions favourable to the growth and action of nitrifying micro-organisms, (3) the presence of potash, and (4) meteorological conditions suitable for the efflorescence of the potassium nitrate at the surface. An ideal combination of these necessary circumstances has made the Bihar section of the Gangetic plain famous for its production of saltpetre.

In this part of India we have a population of over 500 per square mile, mainly agricultural in occupation, and thus accompanied by a high proportion of domestic animals, supplying an abundance of organic nitrogen. With a mean temperature of 78° F., for a large part of the year a comparatively high humidity and a low diurnal range of temperature, the conditions are unusually favourable for the growth of nitrifying organisms. The population largely using wood and cow-dung for fuel, the soil around villages naturally would be well stocked with potash, and finally, with a period of continuous surface desiccation following a small rainfall, the subsoil water, brought to the surface by capillary action in the soil, leaves an efflorescence of salts, in which, not surprisingly, potassium nitrate is conspicuous. Under these conditions India has for centuries been a large producer of saltpetre.

System of manufacture.

The system of manufacture has been very frequently described in detail.[1] Later accounts differ in no essential respect from that given in 1665 by Thevenot.[2] It consists essentially in dissolving out the mixed salts contained in soil around villages, and effecting a first rough separation of the two most prominent salts—sodium chloride and potassium nitrate—by fractional crystallisation. The impure sodium-chloride is consumed locally, whilst the saltpetre is sent to refineries for further purification before export.

[1] *Cf.* C. M. Hutchinson. Saltpetre : Its Origin and Extraction in India, *Agri. Res. Inst., Pusa,* Bull. No. 68 (1917).

[2] Relations of Divers Considerable Voyages, abstract *Phil Trans.* I, 103, (1665).

TABLE 90.—*Quantity and value of saltpetre produced in India during the years 1919 to 1923.*

	1919.		1920.		1921.		1922.		1923.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
Bihar (Refined)	5,044 4	*11,66,268*	3,830 5	*12,24,221*	4,277	*13,96,264*	2,009 1	*5,05,494*	1,622 9	*3,86,243*	3,356 7	*9,35,698*
Do. (*Kuthea*)	2,165	*3,82,970*	1,855	*5,08,415*	2,681	*5,86,464*	1,770	*2,61,423*	1,359 8	*1,98,978*	1,966·1	*3,87,650*
Central India .	47·6	*4,185*	43 8	*2,596*	1·7	*450*	15 8	*3,780*	18	*4,030*	25·3	*3,008*
Panjab . .	5,661·8	*17,13,277*	6,547·6	*25,82,376*	4,339	*19,04,208*	5,038·6	*18,93,015*	3,056·5	*9,76,860*	4,928·7	*18,13,947*
Rajputana .	180	*46,005*	217·1	*63,970*	229	*52,752*	182	*46,487*	..	..	161·6	*47,842*
United Provinces	6,616 2	*17,82,739*	4,379 7	*15,26,961*	4,366	*13,85,340*	2,657·4	*8,12,796*	2,498 2	*6,80,244*	4,103·5	*12,37,616*
TOTAL	**19,715·0**	*50,95,444*	**16,873·7**	*59,08,539*	**15,893·7**	*53,55,478*	**11,672·9**	*35,22,995*	**8,555·4**	*22,46,355*	**14,541·9**	*44,25,761*
Total value in sterling		*£443,082* (£1 = Rs. 11·5)		*£ 590,854* (£1 = Rs. 10)		*£357,032* (£1 = Rs. 15)		*£234,866* (£1 = Rs. 15)		*£149,757* (£1 = Rs. 15)		*£355,118*

TABLE 91.—*Distribution of saltpetre exported during the years 1919 to 1923.*

	1919.			1920.			1921.			1922.			1923.			AVERAGE		
	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of total quantity*
	Tons.	Rs.		Tons.	Rs.		Tons.	Rs.		Tons.	Rs.		Tons.	Rs.		Tons.	Rs.	
nited Kingdom	6,694·9	*23,58,750*	*38·9*	6,789·8	*25,26,420*	*30·7*	4,414·7	*15,10,773*	*34·2*	12,544·9	*7,42,310*	*23 0*	865·6	*2,92,309*	*10·7*	4,262·0	*14,86,112*	*29 9*
eylon . .	2,967·4	*7,60,440*	*17·3*	4,241·7	*11,12,380*	*19·2*	818·8	*2,25,403*	*6·4*	3,100·1	*7,49,349*	*28·1*	2,750·8	*7,00,637*	*34·1*	2,779·8	*7,09,642*	*19·5*
ongkong	2,333·4	*7,47,950*	*13·5*	1,403·6	*4,55,590*	*6·3*	3,262·0	*14,74,118*	*25·3*	2,579·5	*12,60,460*	*23·4*	1,297·4	*5,68,629*	*16·1*	2,175·2	*9,09,349*	*15·2*
apan .	507·2	*2,07,338*	*3·0*	114·6	*35,300*	*·5*	..	..	..	..	..	..	..	..	..	124·4	*48,526*	*·9*
auritius and dependencies	1,976·7	*5,84,630*	*11·5*	4,236·4	*16,85,460*	*15·1*	2,973·2	*10,46,876*	*23·1*	1,811·2	*4,59,461*	*11·9*	2,355·4	*8,35,998*	*29·2*	2,570·6	*9,22,483*	*18·0*
nited States of America .	1,294·8	*3,89,470*	*7·5*	4,334·7	*13,25,030*	*19·6*	750·1	*2,32,580*	*5·8*	218 1	*61,438*	*2·0*	..	..	..	1,319·5	*4,01,704*	*9·2*
ther countries	1,426·1	*4,92,190*	*8·3*	1,011·8	*3,47,330*	*4·6*	674·8	*3,03,722*	*5·2*	1,289·9	*5,04,032*	*11·6*	798·4	*3,09,009*	*9·9*	1,040·0	*3,91,236*	*7·3*
TOTAL .	17,200·5	*55,40,760*	*100·0*	22,132·6	*75,27,400*	*100·0*	12,893 6	*47,93,472*	*100·0*	11,043·7	*37,77,050*	*100·0*	8,067 6	*27,06,582*	*100·0*	14,271·5	*48,69,052*	*100·0*
Total value in sterling.		*£481,805* (£1= Rs. 11·5)			*£752,740* (£1= Rs. 10)			*£319,565* (£1= Rs. 15)			*£251,803* (£1= Rs. 15)			*£180,439* (£1= Rs. 15)			*£397,270*	

The returns for production, although much more complete than formerly, do not always give a true index of the extent of manufacture, the figures for 1920, for instance, showing an excess of exports over production not explainable by invoking accumulated stocks. There has been a heavy and continuous falling off in production during the quinquennium and the figure for 1923 would appear to be the lowest for at least eighty years. All the producing provinces have shared in the reduction. The average yearly export for the five years was 14,271 tons, compared with 21,737 for the war years 1914-1918 when explosives manufacture gave a stimulus to production, and 16,576 tons for 1909-1913. The decline in exports for fertilising purposes is largely attributable to the fact that prices did not compare favourably with those for an equivalent mixture of Chilean nitrate and French potash salts.

Production and exports.

The geographical distribution of exports has resumed its pre-war aspect with one notable exception; the United States, which for many years before the war, was India's largest buyer of saltpetre, now takes an insignificant place in the returns. The United Kingdom was the largest importer, followed by Ceylon—a steady purchaser—Mauritius and Hongkong.

Calcutta is still, as it always has been, the chief port through which saltpetre leaves India, the exports during the period under review having amounted to 88·4 per cent. of the total, as compared with 78·4 per cent. during the preceding period. Karachi's and Bombay's shares of Indian exports during the period under review amounted respectively to 9·3 per cent. and 2·3 per cent. as against 14 and 7·6 per cent. during the preceding quinquennium. The average annual exports from the different provinces during the period 1919-20 to 1923-24 have been :—

Provincial shares in the exports.

	Tons.
Bengal	12,061·1
Sind	1,269·9
Bombay	306·1
Madras	0·5
TOTAL	13,637·6

The use of saltpetre as a fertiliser in the tea districts of North-east India is increasing year by year. The total quantity consumed

during the five years 1919-1923 is in the neighbourhood of 4,000 tons, but it must be taken into account that during the trade slump years of 1920 and 1921, practically no manuring in the tea districts was undertaken and it may, therefore, be said that an average of from 1,300—1,400 tons per normal year represents the present consumption. Saltpetre is now very often included as an ingredient in special tea fertilisers and there are indications that the material will find increased use in future in this direction.

Consumption in India.

Only very small quantities of saltpetre for chemical and medicinal purposes are imported into India by sea, but a considerable quantity comes from Nepal. During the period under review the imports from Nepal as shown below, averaged 3,984 cwts., as compared with 4,595 cwts., during the preceding period.

Trans-frontier imports.

	Cwts.
1919 20	3,071
1920-21	3,558
1921-12	9,661
1922-23	675
1923-24	2,955
Average	3,984

The annual values returned for the total imports give an average of Rs. 30,305 which is equivalent to Rs. 7·61 per cwt.

Tin.

[J. COGGIN BROWN.]

The cassiterite deposits of Burma, which furnish practically the whole of India's production of tin have been worked from a remote antiquity, especially in the districts of the Lower Tenasserim division. The region through which the Burmese tin ore is disseminated, corresponds exactly with that described in another section of this review in the case of wolfram, for the ores of tungsten and tin are most intimately associated and are of identical origin. The granitic mountain ranges of Lower Burma are the northern continuation of the same rocks which have yielded the rich and well-known tin-stone deposits of the Malay Peninsula and Western Siam. The sporadic occurrences of cassiterite in India proper are not of any economic importance.

Tenasserim deposits.

Production.

The prolonged stagnation of the wolfram industry during the period under review has fortunately not interfered with the progress of tin mining, and the comparatively high prices which have prevailed for part of the time for metallic tin have made the extraction of cassiterite profitable, although operations in the case of wolfram could no longer be carried on. It has been pointed out in previous years that ores from mines in Burma are shipped as "mixed concentrates", and actually contain varying proportions of wolfram and tin-ore. In normal times a certain amount of tin-ore thus escapes tabulation and goes to swell the wolfram, or tungsten ore, returns. In the absence of the assay results on which the parcels are sold but which are not officially given to the Administration, it is impossible to arrive at exact figures for each. It is easy enough to correct the figures in the case of districts where the output comes from one or two mines and make them approximately true by taking the average composition of the concentrates over a number of years, but in other instances, where the ores are derived from a large number of small mines, this cannot be done, as the composition of the parcels varies from time to time with the seasons or according to the rise and fall in price or to other factors. However, during the quinquennial period 1919-1923, the probability is that the returns refer to purer tin-ore than usual, for wolfram has been practically unsaleable; a greater proportion of the output than usual has been derived from alluvial deposits which yield the ore alone, while a great deal of the yield is submitted to magnetic treatment for the separation of the wolfram before shipment.

Metallic tin, or "block tin" as it is termed,—an unfortunate phrase, too liable to be confused with "black tin," a common trade name for dressed cassiterite—is made in the Mergui district by smelting the ore in Chinese furnaces. Accepting the figures for the metal as they stand, the production has increased from 137 tons, valued at Rs. 4,88,183 in 1919 to 218 tons, valued at Rs. 5,33,395, in 1922, giving an average of 138 tons, valued at Rs. 4,15,295, per annum, compared with an average of 116 tons, valued at Rs. 3,38,040, per annum for the period 1914-18. Omitting the large shipments of low-grade ore from Mergui in 1920, which it is necessary to do in order to obtain a propei perspective of the the position, the total output of cassiterite concentrates has risen from 1,569·3 tons, valued at Rs. 20,29,223, in 1919 to 2,007 tons, valued at Rs. 27,84,611, in 1923,

TABLE 92.—*Production of Tin and Tin-ore in India during the years 1919 to 1923.*

		Amherst.		Mergui.		Southern Shan States.		Tavoy.		Thaton.		Hazaribagh.		Total.	
		Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
		Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
1919 .	Tin .	..	..	137·1	*4,88,183*	..	..	..	..	..	..	..	..	137·1	*4,88,183*
	Tin-ore	61·6	*86,040*	210·2	*4,10,138*	527	*6,66,115*	713	*7,58,737*	57·5	*1,19,193*	..	..	1,569·3	*20,29,223*
1920 .	Tin .	..	..	163·3	*5,92,793*	..	..	..	..	..	..	..	..	163·3	*5,92,793*
	Tin-ore	41·5	*49,200*	866·2 (a)	*5,74,658*	628·5	*7,64,248*	1,063 (b)	*11,69,366*	18·4	*19,102*	1·6	*2,847*	2,119 2	*25,69,421*
1921 .	Tin .	..	..	171·2	*4,62,104*	..	..	..	..	..	..	..	..	171·2	*4,62,104*
	Tin-ore	30·9	*30,948*	409·9	*5,95,306*	9 8	(c)	1,250	*13,62,227*	1·0	*960*	..	..	1,701·6	*19,79,441*
1922 .	Tin .	..	..	217·8	*5,33,395*	..	..	..	..	..	..	..	..	217·8	*5,33,395*
	Tin-ore	11·8	*16,339*	407·6	*5,87,184*	..	..	1,445	*16,83,728*	10·3	*13,790*	..	..	1,874 7	*23,01,041*
1923 .	Tin .	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Tin-ore	3·2	*2,002*	527·8	*8,07,923*	..	..	(d)1,478	*19,70,786*	3·0	*3,900*	..	..	2,007·0	*27,84,611*
Average	Tin .	..	..	137·9	4,15,295	..	..	..	..	..	..	..	..	137·9	4,15,295
	Tin-ore	29·8	36,706	384 3	5,95,042	233 0 (d)	2,82,072 (d)	1,189	13,86,969	18·0	31,389	0·3 (e)	569 (e)	1,854·4	23,32,747

(a) Excludes 1,220 tons of low-grade ore valued at Rs. 91,500.
(b) Excludes 3 tons of low-grade ore valued at Rs. 2,550.
(c) Not available.
(d) Excludes the production of 4·38 tons of low-grade ore.
(e) Average of five years.
* Excludes the value of 11 tons.

being an average of 1,854·4 tons, valued at Rs. 23,32,747, per annum, compared with an average of 483 tons, valued at Rs. 7,62,600 per annum, for the period 1914-18. These increases are both remarkable and gratifying, and fully justify the writer's prediction in the last review that a large increase in the output of the ore from Tavoy and other parts of Tenasserim should be registered in the next quinquennial period.

TABLE 93.—*Consumption of Foreign Block Tin in India.*

Year.	Imports.		Re-exports.	Consumption.
	Quantity.	*Value.*		
	Cwts.	*Rs.*	Cwts.	Cwts.
1918-19	28,086	*56,09,100*	1,650	26,436
1919-20	46,835	*78,02,170*	5,722	41,113
1920-21	41,783	*65,88,060*	376	41,407
1921-22	53,737	*75,29,195*	655	53,082
1922-23	43,295	*54,50,055*	278	43,017
Average	*42,747*	*65,95,716*	*1,736*	*41,011*

TABLE 94.—*Exports of Burmese Block Tin and Tin-ore for the years 1918-19 to 1922-23.*

—	Block Tin.		Tin-ore.		Total.	
	Quantity.	*Value.*	Quantity.	*Value*	Quantity. Tin-ore (*a*)	*Value.*
	Cwts.	*Rs.*	Cwts.	*Rs.*	Cwts.	*Rs.*
1918-19	..	..	7,420	*9,33,405*	7,420	*9,33,555*
1919-20	..	..	11,560	*11,78,080*	11,560	*11,78,080*
1920-21	..	..	19,180	*21,97,380*	19,180	*21,97,380*
1921-22	290	*46,979*	32,060	*30,16,346*	32,495	*30,63,325*
1922-23	..	..	31,800	*33,62,748*	31,800	*33,62,748*
Average	*58*	*9,396*	*20,404*	*21,37,622*	*20,491*	*21,47,018*

(*a*) 3 cwts. of the ore are assumed to be equivalent to 2 cwts. of block tin.

The consumption of tin is rapidly increasing in India—a state of affairs due in some measure to the inauguration of the tin plate industry at Jamshedpur. The imports of foreign block tin, the largest quantity of which continues to come from the Straits Settlements, varied from 28,086 cwts., valued at Rs. 56,09,100, in 1918-19 to 53,737 cwts., valued at Rs. 75,29,195, in 1921-22. Table (93) shows the imports, re-exports, and apparent consumption of foreign tin in India.

Consumption.

A considerable literature exists on the geology and ore deposits of the Mergui district, and there are references to the occurrences of tin-ore here in the writings of the following authors:—J. Low (1829), J. W. Heefer (1839), G. B. Tremenhere (1841, 42, 43), E. O'Riley (1849), F. Mason (1850), T. Oldham (1856), M. Fryar (1872), F. Mason and W. Theobald (1882), R. Parry (1897), T. W. H. Hughes (1888 and 1893), to mention only the earlier ones. These observations and the results of the work of a still larger number of later writers have been summarised by the writer and Dr. A. M. Heron in a report entitled "The Geology and Ore Deposits of the Tavoy District" [*Mem. Geol. Surv. Ind.*, Vol. XLIV, pt. 2 (1923),] which should be referred to for further details. It is remarkable that practically all the Mergui wolfram deposits carry cassiterite; indeed it may be stated as a general rule, to which, however, there are certain exceptions, that the further south one travels in the great ore-province of Tenasserim, the more prevalent does cassiterite become at the expense of wolfram in the association of the two minerals. Alluvial deposits of cassiterite are widely distributed over the Mergui district, and much of the output is won by small concessionaires operating primitive ground-sluicing methods. The better known localities are Karathuri on the coast and Thabawleik on the Little Tenasserim River. Numerous areas have been taken up at various times over the gravels of the Lenya and Pakchan Rivers, near Kazat and Kyumon in the delta of the Tenasserim, in the vicinity of Palaw and Palauk which lie to the north of Mergui town, and in certain islands of the archipelago. On Spider Island, at the mouth of Palauk River there is an interesting area from which concentrates containing cassiterite and wolfram in about equal quantities were won on the sea beach and from below high-water level in a mangrove swamp. The minerals are derived from thin irregular veins traversing a little hill rising above the swamp.

Mergui District.

During the progress of the systematic geological survey of the Mergui district, which has been continuously carried on during the last five years, tourmaline-muscovite-pegmatites locally carrying cassiterite but never wolfram, have been found in various places cutting both the granites and sedimentary rocks into which they are intruded. Both cassiterite and wolfram display a tendency to deposit in thin stringers or leaders, and little veinlets, half-an-inch or so in thickness, are often found which reproduce the internal structures of large veins. Such stringers are for their size often excessively rich, and patches of ore occur in them which are practically solid. When such veinlets occur in close association in soft ground, they may form a valuable source of these ores. Much of the so-called "alluvial" concentrate won by sluicing residual or decomposed rock is derived from the very numerous stringers and mineralized cracks penetrating it both in Mergui and Tavoy.

The size of the grains of Burmese stream tin depends entirely on the distance the mineral has travelled from its original home. In the upper parts of the valley, where little classification of the river deposits has taken place and where there is still much unsorted detrital matter, individual crystals of about the same size as that of a coffee bean, with their edges rounded, can be picked out of the finer material. Further down stream still, smaller, rather angular fragments are characteristic, but in the real alluvial sands and gravels the fine concentrated ore develops a rounded form. Here it is associated with magnetite, ilmenite, topaz, garnet and zircon, and sometimes with small amounts of monazite and gold.

Attention has been drawn in earlier reports to the Maliwun vein deposits. Originally worked by the Chinese and later by European companies, the mine was lavishly equipped with modern machinery, but it has never been able to pay, and the hydro-electric generators with mill, compressor, hydraulicing plant and electric trams were quickly rusted in the jungle, while a gang of Chinese tributers returned to their former practices. The quartz veins and greisen bands at Maliwun are in granite very close to its margin with the Mergui sediments, and they contain much white mica and some pyrite, chalcopyrite and arsenopyrite. Tourmaline has also been recorded.

Geological conditions in Tavoy district are much the same as those in Mergui. Granite intruded into an ancient sedimentary series forms the cores of the mountain ranges; quartz veins and pegmatites carrying wolfram,

Tavoy District.

cassiterite, molybdenite, bismuth, bismuthinite, and a large variety of sulphides, cut through them both. These minerals occur also in the alluvial deposits of the hill-sides, where veins are undergoing degradation, and in the coarse unsorted debris of clay, rotten rock and boulders, which tend to accumulate at the heads of the flatter valleys. Cassiterite is found too in the water sorted alluvial deposits, the gravels and sands of the lower portions of the streams. Since the publication of the last review, much has been written on the geology, mineralogy and mining economics of the Tavoyan deposits, and detailed descriptions of all the mines are given in the memoir already referred to.

Though Tavoy is primarily a wolfram-producing region, there are areas within it richer in cassiterite than the rest, and it is from these and from the extension of dredging operations that the large increase in tin-ore has been recorded. Amongst these areas the following deserve especial mention: Hermyingyi, Kanbauk and Taungpila.

Tin dredging operations on the Hindu Chaung have been greatly developed during the period. In 1918, the property, which had been worked up to that time by means of a suction dredge by Messrs. Booth and Milne, was acquired by the Indo-Burma Tin Corporation, Limited. This concession had already purchased the four bucket dredgers which were formerly employed in gold dredging on the upper reaches of the Irrawaddy in Myitkyina district. Two dredgers each with a capacity of 45,000 cubic yards per mensem, were dismantled, transported to Tavoy and re-erected by the end of 1920. A smaller dredge, with a capacity of 22,000 cubic yards per annum, has since been set up on the concession between the two former ones, while a fourth, the largest of all, with a capacity of 75,000 cubic yards per mensem, remains out of commission pending the proving of a suitable location for its activities. The general yield of the Hindu Chaung gravels per cubic yard was estimated at 1·10 to 1·25 lbs. of cassiterite by systematic boring surveys, but in practice better results than this have been obtained; thus, for the six months ending April 1923, the average yield of all material dredged worked out at 1·68 lbs. per cubic yard. Bucket-dredging for tin-ore has thus become an established industry in Tavoy, and it is anticipated that the profitable results shown by this Corporation will lead to its extension to other suitable areas, such as those which have been indicated from time to time by officers of the Geological Survey of

India as being well worth systematic testing by regular boring campaigns.

The output of tin-ore from the Amherst district has fallen from 61·6 tons in 1919 to 3·2 tons in 1923. The Amherst district is largely a plains country, but running through it there are three continuous ranges which converge in the south and join the *massif* where Amherst, Tavoy and Siam meet. The geology of the district is imperfectly known, but the two outermost ranges appear to be made up of slates, quartzitic sandstones, grits and impure limestones, which recall vividly the lithological types of the Mergui series of Tavoy and Mergui. In the broad valleys between the ridges there are extensive spreads of Moulmein limestones of Carboniferous age. The Dauna Range does not belong to the same geological province, as it is composed of coarse banded gneisses and schists with gneissose granites.

Amherst District.

On Belugyun island at the mouth of the Salween river the tin-ore deposits are on the lower slopes of argillaceous quartzites, which form the backbone of the island. These rocks are penetrated by veins of tourmaline-garnet pegmatite, fine-grained, foliated tourmaline granite and drusy white quartz. The cassiterite may come from any or all of these. The other localities are west and east respectively of the Seludaung range which divides the coastal plain from the valley of the Winyaw, a tributary of the Ataran. Various concessions on which alluvial cassiterite occurs have been taken out around Sakaugyi village and near Paya and Hlutsha to the south-south-east of Seludaung G. L. S. The tin-ore appears to come from the granitic rocks which pierce the sedimentary strata in these regions.

The output of tin-ore from the Thaton district continues to be very small, and has declined from 57·5 tons in 1919 to 3 tons in 1923. In 1921 only 1 ton was recovered. The producing areas are situated on or near the long ridge which runs parallel to the railway from Pegu to Martaban, and are at the extreme ends of the wolfram-bearing areas. The output appears to be entirely of an alluvial character and to be derived from small veins and thin stringers in the underlying rocks.

Thaton District.

The output of tin-ore from the Southern Shan States is practically all derived from the Mawchi mine, which is situated in the southern

Southern Shan States.

portion of the Bawlake State of Karenni. The mine reached its maximum production of 404 tons in 1917, which rose to 527 tons in 1919 and to 628·5 tons in 1920. In the next year the output fell to 9·8 tons only and since then activities ceased owing to the depression in the market.

At Mawchi there are at least ten important veins, varying from 2½ to 5 feet in thickness, in granite capped with limestone and flanked by slates, and carrying cassiterite, wolfram, arsenopyrite, pyrite, chalcopyrite and black tourmaline. The mine was very well equipped and underground exploitation was probably carried on here at a greater depth below the outcrops of the veins than on any similar deposit in Burma.

Indian Occurrences.

The production of tin-ore in India proper excluding Burma, is limited to the insignificant amount of 1·6 tons from the Hazaribagh district of Bihar and Orissa in 1920. This was probably derived from the Nurunga deposit, where the ore occurs in the unusual form of a cassiterite granulite. The mineral has also been found in the mica-bearing pegmatites of the province of Bihar and Orissa at Pihra and near Domchanch in the Hazaribagh district, but these occurrences are of no economic importance.

Tungsten.

[J. COGGIN BROWN.]

The unprecedented demand for tungsten ores caused by the use of high-speed steels in munitions manufacture during the War, which characterised the previous quinquennium, was succeeded during the period under review by a collapse of the market resulting in the cessation of such mining operations as were conducted in Burma for the extraction of wolfram alone.

History.

As matters of historical interest, it may be recalled here that the earliest records of the occurrence of wolfram in the Tavoy district of Burma dated back to the forties of the last century and refer mainly to the efforts of misguided individuals to extract tin from the mineral. These early events were forgotten, and it was not until 1908 that wolfram was

TABLE 95.—*Production of Tungsten-ore in India during 1919 to 1923.*

—	1919.		1920.		1921.		1922.		1923.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*	Tons.	*Rs.*
Bihar and Orissa—												
Singhbhum .	1·5	*3,567*	..	..	..	..	..	..	..	..	(*b*) 0·3	*773*
Burma—												
Kyaukse .	0·2	*100*	..	..	..	..	..	..	..	..	..	(*b*) *20*
Mergui .	346·7	*5,20,921*	191·5	*1,73,352*	4·9	*1,597*	4·75	*4,274*	0·2	*52*	109·6	*1,40,039*
Southern Shan States.	397·6	*5,72,544*	474·2	*2,63,178*	7·4	(*a*)	..	..	..	..	(*b*) 175·8	*1,67,144*
Tavoy .	2,730·7	*40,14,139*	1,679·0	*9,59,420*	886·0	*4,37,791*	938·0	*3,71,048*	871·8	*4,79,641*	1,421·1	*12,52,408*
Thaton .	48·1	*1,00,370*	1·5	*1,125*	..	..	0·25	*210*	..	..	(*b*) 10·0	*20,341*
Rajputana—												
Marwar .	45·5	(*a*)	..	..	..	..	..	..	..	..	(*b*) 9·1	(*a*)
TOTAL .	**3,570·3**	*52,11,941*	**2,346·2**	*13,97,076*	**898·3**	*4,39,388*	**943·00**	*3,75,532*	**872·0**	*4,79,693*	**1,725·9**	*15,80,725*
Value in sterling		*£453,212* (£1 = Rs. 11·5)		*£139,707* (£1 = Rs. 10)		*£29,292* (£1 = Rs. 15)		*£25,035* (£1 = Rs. 15)		*£31,979* (£1 = Rs. 15)		*£135,845*

(*a*) Not available. (*b*) Average of five years.

rediscovered by an officer of the Geological Survey of India. From that time onwards the industry slowly developed through many vicissitudes until Lower Burma headed the list of the world's producers. She occupied this position in 1914, when 2,243 tons were extracted, of which Tavoy alone yielded nearly 2,000 tons. At that time Great Britain was dependent upon Germany for supplies of ferro- and metallic tungsten, but after the outbreak of war, various large tungsten-producing plants were erected in England, a shortage of the essential raw material became apparent, and steps were taken which at once led to intensive mining operations in Burma and elsewhere. The response to the decision of the Imperial Government to take over all available supplies at a fixed rate of 55 shillings per unit of WO_3, on a basis of 65 per cent. ore, was neither immediate nor satisfactory. Mining methods were, with few exceptions, exceedingly primitive, the labour force was hopelessly under-manned, means of communication and transport were difficult and slow, and there was much lack of enterprise generally. Towards the end of 1915 it was apparent that drastic action was necessary, and it devolved upon a special corps of officers of the Government of Burma and the Geological Survey of India to administer the new policy. That the measures were successful is shown by the increase in Burma's output to 3,650 tons in 1916, an amount which was more than double that of any year previous to the war. Larger outputs than these were recorded in 1917 and 1918, the average for the quinquennial period 1914 to 1918 for the whole of India being 3,473 tons.

Output.

In the first year of the present period 3,570 tons, valued at Rs. 52,11,941 were produced; in 1920, 2,346 tons valued at Rs. 13,97,075. This marked the end of active operations, for in 1921 the output was only 898 tons valued at Rs. 4,39,388. Table (No. 95) shows the distribution of the sources of production and demonstrates clearly that the Tavoy district continues to hold the preponderating position it has always occupied.

It is now necessary to deal in somewhat greater detail with the events which have brought about the present stagnation. After the 31st May, 1919, the Ministry of Munitions ceased to buy wolfram on the basis of the war time contract, and in lieu thereof awarded compensation to firms and individual concessionaires on the basis of the estimated outturn for the next six months, had the guarantee

to purchase continued. The price of wolfram in the open market also fell to a very low figure, and the output declined. One result of this was that the services of a large part of the labour force built up during the War were no longer required, and many of the Chinese and Indian coolies left the district.

During 1920, the decrease of some 38 per cent. in the Tavoyan output was the inevitable result of the continued depression of the market. Some of the larger firms engaged in wolfram mining closed down their operations, while very few of the smaller mine-owners continued to win ore, their activities being practically entirely confined to tin stone.

Throughout the following years of the period under review, the decline continued. Companies on whose leases only pure wolfram is to be found have ceased operations entirely, as the price of the mineral is so low that it cannot be worked profitably. The few hundreds of tons per annum, which now appear in the returns, represent the amounts which are won incidentally in the form of mixed concentrates, which are mined solely for their tin content, the wolfram at present being unsaleable.

The trend of events in other tungsten-producing countries of the world, with the single exception of China, has been much the same.

Other countries.

Thus, by 1919, the industry in the United States, which for some years struggled with Burma for the first position on the list, was almost completely paralysed and continued more or less in this condition until 1922 when a protective Tariff Act imposing high duties on imported concentrates led to the commencement of a slight revival. The situation in Bolivia, the Argentine and Peru, in Portugal and the British Isles, and in the producing States of Australia has passed through identical phases, and were it not for the occurrence of tin-ores with the tungsten mineral in some of these cases, similar to the close association of the elements in Burma, and for the high prices that have ruled for metallic tin during part of the time, it is doubtful whether the few hundreds of tons that have been won would have been registered at all.

Though this is not the place to discuss in detail the mineral industries of foreign countries, a passing reference must be made to the extraordinary history of China as a tungsten-producing region. Before 1916, the occurrence of wolfram in China was unknown, but the large quantities produced in 1918, estimated at over 10,000

tons of 60 per cent. concentrates, or twice the production of any single country in any preceding year, made it evident that the Chinese deposits are of very considerable value and will eventually be serious competitors for the world's market. Although the slump in the wolfram business affected China, as well as every other producing country, and reduced the high figures of 1918 to 3,500 tons by 1921, the output has risen again, and out of a world's total of 10,700 tons in 1922 China is believed to have furnished at least 7,000 tons, exported to Germany, the United Kingdom and the United States at a time when the prices ruling for the commodity made mining operations unprofitable in most other countries. The large tonnages of Chinese wolfram have been derived from shallow surface deposits distributed in many scattered regions in the provinces of Hunan, Kiangsi, Kwangtung and Chili. Recent authorities state that these deposits are by no means exhausted, that the parent veins have scarcely been touched, while the fields generally are only partially prospected. The deposits are readily accessible, costs, transportation and labour are cheap; indeed it has been stated repeatedly that most of the mineral is won by agriculturists working in their spare time. There appears indeed to be little doubt that the first place as a potential wolfram-producing country must now be definitely allotted to China.

Occurrence in Burma.

Quartz veins containing wolfram have been found at intervals over a distance of 750 miles in Burma from the Yengan and Mawnang States of the Southern Shan States through the districts of Kyaukse, Yamethin, the State of Karenni, Thaton, Amherst, Tavoy and Mergui. In all these localities the wolfram- and cassiterite-bearing veins are closely associated with a biotite boss-granite, which forms the core of the ranges of the Indo-Malayan mountain system stretching further to the south through Western Siam to the Malay Peninsula. The granite is intruded into a series of hardened and crushed shales, slates, argillites and agglomerates with greatly subordinate quartzites, limestones and conglomerates known as the Mergui series. These rocks are of unknown age, and are characterised by monotonous uniformity of type over great areas and over an immensely thick mass of strata. In its typical exposures, though it varies considerably in granite texture, the granite is extraordinarily uniform in composition. It contains abundant quartz, both orthoclase and acid plagioclase, while the mica is usually biotite. Towards the peripheries

of the intrusions, the rock becomes finer-grained than the porphyritic and coarse varieties nearer the centres; biotite is scarcer, and muscovite takes its place. Hornblende is rare and accessory minerals are very uncommon. Pseudo-foliation is often developed near the contacts, and has led some earlier observers to mistake portions of the rock for gneiss.

Both wolfram and cassiterite occur very sparingly as accessory minerals in the granite; they are also found in aplite and pegmatite veins traversing it and in the greisens, the narrow bands of quartz-mica rock formed by the alteration of the granite adjoining the true quartz veins. These modes of occurrence are of more theoretical interest than practical importance, and, with the exception of the surface deposits, furnish the great bulk of the concentrates from Burma. Mineral-bearing quartz veins are found either in the granite, penetrating its contact with the sedimentary rocks or enclosed within the latter rocks themselves at no great distance from the granite. The veins were formed by the infilling of fissures, and often occur in parallel groups of overlapping lenses. The lenses themselves are often irregular, thinning out and thickening again, splitting and then re-uniting. There is every variation from great veins traceable for miles on the surface to mere stringers. The general strike follows that of the main mountain trend, and is north and south to north-east and south-west. Dips are usually high.

In different parts of Burma, the mineral associates of wolfram are not the same. Beryl has only been found at Byingyi in the Yamethin district. Tourmaline is common at Mawchi in Karenni, in the Thaton district, and in parts of Mergui; in Tavoy it is unknown in conjunction with wolfram or cassiterite. Here, in addition to these minerals, the quartz veins carry mica (practically always), fluorite (often), molybdenite (sometimes). pyrrhotite (in some cases), galena (rare), zinc blende (rare), arsenopyrite (rare), native bismuth (rare). bismuthinite (rare), and topaz (in one case only). In the Tavoy district alone there were over 100 producing concessions in 1918, which ranged from shallow workings operated by primitive Chinese methods to deep mines, fully equipped with the most modern concentrating plants. The largest mines were Hermyingyi, Kanbauk, Widnes, Pagaye, Paungdaw, Taungpila and Kalonta[1].

[1] *See* J. Coggin Brown and A M. Heron: "The Geology and Ore Deposits of Tavoy" (*Mem. Geol. Surv. Ind.*, Vol. XLIV, Pt. 2 (1923).

The chief wolfram deposits of the Mergui district are near Palauk in the north, and at Tagu near the Great Tenasserim River, some 70 miles from its mouth. The veins of the Tagu area are remarkable for their large size, varying from 3 to 15 feet in thickness ; they are all in granite, and carry arsenopyrite and chalcopyrite. The veins of the Maliwun area, too, in the extreme south of Mergui district are in granite, but in the Palauk area the veins occur in both granite and sedimentary rocks.

The wolfram-bearing veins of Thaton are in two well-marked series—one in granite, and the other in the quartz, the sandstones of the long mountain ridge which runs parallel to the coast through this district. They differ markedly from those of Tavoy, in that they carry tourmaline. Four parallel veins, only a few inches thick, have been traced for the unusual distance of 2½ miles.

The well-known Mawchi mine is situated in the southern portion of the Bawlake State of Karenni. It possesses at least ten important veins varying from 2½ to 5 feet in thickness, which are all in granite.

The wolfram-bearing area of the Yamethin district is situated close to the summit of Bymgyi, a peak which rises 6,254 feet above sea-level on the borders of Yamethin and the Loi Long State. The veins are in granite, and carry wolfram, molybdenite and beryl.

In the concessions of the Myelat division of the Southern Shan States, granites, clay slates and quartzites are penetrated by veins carrying wolfram, molybdenite and copper, and iron compounds[1].

Although further discussion is impossible here, it is hoped that the brief notes given will demonstrate clearly how closely all the wolfram and cassiterite deposits of Burma are associated with the intrusive granite already mentioned. It is believed that the deposits were formed partially under conditions closely allied to strictly magmatic ones, and were also produced by processes in which gaseous agencies, including compounds of fluorine and sulphur, to some extent played a part, and, in rare cases, by hydrothermal reactions which followed as a consequence of the former ones. Thus, the whole process of mineral-vein formation, associated with this great granite chain, appears to be a direct sequence of processes of differentiation or fractional crystallization, through a varying series of

[1] For fuller details *see* : "The Distribution of the Ores of Tungsten and Tin in Burma", by J. Coggin Brown and A. M. Heron, *Rec. Geol. Surv of Ind.*, Vol. L, pp. 117-129 (1919), and " A Geographical Classification of the Mineral Deposits of Burma, by J. Coggin Brown, *Rec. Geol. Surv. Ind.*, Vol. LVI, pp. 65-108 (1924).

phases, influenced by local conditions and induced in the original magma by decreasing temperature.

The wolfram-bearing quartz veins, which occur near Kalimati in the Singhbhum district of Bihar and Orissa and yielded 30·5 tons between 1916 and 1918, produced only 1·5 tons in 1918, when operations were closed down.

Singhbhum.

Wolfram occurs with coarsely crystalline mica, ilmenite and fluorite, in thin quartz veins which traverse granite at Degana in the Marwar district of Rajputana. Under the stimulation of war conditions, over 100 tons were produced here during the years 1916-1918. In 1919 the output was 45·5 tons, since when, no further returns have been forthcoming, and it is presumed that mining has ceased.

Rajputana.

Zinc.

[J. COGGIN BROWN.]

Zinc concentrates are produced at the milling plants of the Burma Corporation, Limited, of Nam Tu, Burma. The zinc blende occurs as an intimate mixture associated with galena at the Bawdwin Mines. (*See* Lead.)

The exports of zinc concentrates during the period have been as follows :—

	Tons.	Value. Rs.
1919	0·25	390
1920	75	3,040
1921	4,000	3,00,139
1922	18,061	13,57,571
1923	2,062	1,73,756

These figures give little indication of the production but represent merely the quantities which have been disposed of for conversion into spelter in Belgium, to which country all the parcels are shipped. In the years 1913 and 1914 considerable quantities were shipped to Belgium and Germany and in 1916 over 3,000 tons went to Japan.

The total exports for the last quinquennium were 24,198 tons valued at Rs. 18,34,896.

The proposal to smelt the Burmese zinc concentrates at Jamshedpur and to recover the sulphur in the form of sulphuric acid, which was mentioned in the last review, has not eventuated. During the period, however, extensive investigations have been made into the most economical method of producing marketable zinc concentrates at Nam Tu, a special experimental flotation plant being installed for the purpose, and it is anticipated, especially in view of recent developments in the spelter industry in the United Kingdom, that the regular shipment of Burmese concentrates in large quantities may become a feature to record in the future, unless the Indian sulphuric acid project is revived.

IV.—MINERALS OF GROUP II.

Alum and Aluminous Sulphates.

[C. S. FOX.]

Meaning of terms.

If the name Alum is restricted to those double salts containing alumina, as the sesquioxide, with the sulphates of potassium, or sodium, or ammonium, and twenty-four molecules of water of crystallisation, then it can be definitely stated that no workable deposits of natural alum have so far been discovered in India. Of the other mineral substances which can be grouped under the generic name of alum there is no information to show that such material occurs in India in quantities which would justify exploitation. The potash alum, *Kalinite* ($Al_2O_3(SO_3),K_2SO_4,24H_2O$) has been found in small quantities in some places. The mineral *Alunite* ($3Al_2O_3(SO_3)$ $K_2SO_4,6H_2O$) has been noted in association with sulphur in the Sanni mines of Baluchistan. The natural substances *Alunogen* ($Al_2O_3(SO_3)$ $18H_2O$) and *Aluminite* ($Al_2O_3(SO_3)$ $9H_2O$), are not alums, but are largely used in some countries for the preparation of alum; however, so far as is known these minerals are not available from extensive domestic deposits for this purpose in India.

Practically all the alum which is produced in India is made by the separation of sulphate of alumina from decomposed pyritous shales,

Manufacture. with the addition of nitre or wood-ashes, to provide the hydrated double sulphates of alumina and potash, or of alumina and soda. At one time this was a relatively important local industry in certain parts of India, but the importation of cheap alum and the easy distribution of this article from the railways has resulted in the practical extinction of the native industry in most localities. Among the more important places where alum used to be manufactured may be mentioned:—Phulwaria in the Shahabad district of Bihar; Mhurr in Kachh (Cutch) and Maki Nai in Sind in the Bombay Presidency; Khetri and Singhana in Jaipur State in Rajputana; and Kalabagh and Kotki in the Mianwali district of the Punjab. Today the only locality in which alum is prepared on a commercial scale and from which returns are available is Kalabagh. A detailed account of the methods in use at this locality was given by the late Mr. N. D. Daru (*Rec. Geol. Surv. Ind.*, XXXVIII, (1909), p. 32; also XL, (1910), pp. 265-282). In the Salt Range near Kalabagh, alum shales are found at two distinct horizons in the Eocene (nummulitic) series, and again at the base of the underlying Jurassic series. Only one of these beds, situated at or near the base of the Eocene, is sufficiently rich in sulphur content to be used for alum making. The thickness varies from 7 or 10 feet at Kalabagh to 25 or 40 feet at the Chichali pass near Kotki, a distance of 9 miles. About a mile beyond the latter locality it appears to die out. The pyrites is disseminated through the shales in microscopic particles, and the proportion of sulphur varies greatly, from 2 to nearly 13 per cent. Workable shale, known as *rol*, contains an average of 9·5 per cent. of sulphur, and is distributed in patches through the bed. Mining is conducted on no systematic plan, but the mineral is extracted by means of narrow, tortuous passages, rendered unbearably hot by reason of the decomposition of the pyrites, and without any provision either for ventilation or drainage.

The shale brought from the mines is built up with layers of brushwood, and of clay that has been once burnt and exposed to the weather for at least a year, into heaps about 18 feet high, and roasted, fresh layers being added at one side of the heap, while the other is cut out for leaching. The burnt clay is added in order to absorb as much as possible the sulphurous fumes from the fresh shale, but much of the sulphur is lost by volatilisation.

The process of lixiviation is somewhat complicated. The roasted shale is steeped in water for two days in tanks (*gádán*), lined with a mixture of re-burnt wood-ashes, lime and cowdung, and the liquor is run into a settling tank (*chorh*), where it remains for 24 hours. In the meantime another portion of burnt shale has been steeped for 24 hours with some of the mother liquor from the crystallisation tanks in a smaller tank (*toi*). The solution from the *chorh* and *toi* are then boiled together for an hour in large iron pans, and run into a final settling tank (*nitar*), which is filled with the remainder of the mother liquor. After resting for 8 hours, half the contents of the *nitar* are boiled for 3 hours, when a certain proportion of *shora*, a mixture of chlorides, nitrates, and sulphates of soda and of potash, with traces of carbonates, obtained from leaching out the efflorescent soil found at various places in the district, is added. Boiling is continued for another 7 hours, when the contents of the pan are transferred to a crystallising tank, and the pans are filled with the liquor remaining in the *nitar*. The crude crystals are removed after 5 or 6 days, and are purified by fusing them for 2 hours in their water of crystallisation. The liquor is finally crystallised in large earthenware jars half sunk in the ground.

It is interesting to compare the above description with that given for European practice, in Thorpe's Dictionary of Applied Chemistry, Vol. I, (1921), p. 176. Daru pointed out that the use of lime in the lixiviating tanks results in a very considerable loss of alum, and that this would be avoided by lining them with gypsum, which is found in abundance at Kalabagh itself. The product of the above manipulations is mainly soda-alum which is used at Delhi, Hissar, Sirsa, and other centres of the tanning and dyeing industries.

Pyritous shale suitable for the manufacture of alum has been noted in association with the coal seams of Makum, Lakhimpur district, Assam; Dandot colliery, Jhelum district, Punjab; and elsewhere in India. In view of the tendency to use aluminium sulphate in place of alum and its manufacture from bauxite it is likely these pyritous shales will not be worked in an extensive manner in the near future.

The annual production of alum during the past five years is given in the following table. The entire output is from the Mianwali district, Punjab.

TABLE 96.—*Indian Production of Alum during the years 1919 to 1923.*

Year.	Quantity.	Value.	
	Cwts.	Rs.	£
1919	1,853	*48,000*	4,174(*a*)
1920	2,691	*73,200*	7.320(*b*)
1921	3,380	*64,400*	4,293(*c*)
1922	6,632	*99,760*	6,651(*c*)
1923	3,456	*64,472*	4,298(*c*)

(*a*) £1=Rs. 11·5. (*b*) £1=Rs. 10. (*c*) £1=Rs. 15.

TABLE 97.—*Imports of Aluminous Sulphates and Alum during the years 1919 to 1923.*

Year.	Alum.		Aluminous Sulphate.	
	Quantity.	Value	Quantity.	Value
	Cwts.	Rs.	Cwts.	Rs.
1919 . . .	51,915	6,65,010	64,312	4,73,040
1920 . . .	85,561	10,18,270	100,351	7,65,280
1921 . . .	38,235	5,38,112	47,272	4,43,808
1922 . . .	73,226	8,75,198	57,681	4,65,371
1923 . . .	68,094	6,87,934	56,275	3,99,327
Average .	63,406	7,56,905	65,178	5,09,365

The above table shows that aluminous sulphates are on an average cheaper than alum. This point is of some importance in view of the fact that in most of its applications alum can and is being replaced by aluminium sulphate. In this connection it is interesting to note that fairly large quantities of sulphate of alumina are annually prepared in India by treating bauxite with

sulphuric acid. Messrs. D. Waldie & Co. of Calcutta state that they use about 800 tons of raw bauxite annually in the production of 600 tons of alum cake; 1,000 tons of sulphate of alumina (15 per cent.); and 800 tons of alum crystal, at their Konnagar and Cawnpore factories.

The substitution of bauxite for china clay in the manufacture of aluminium sulphate is fully discussed in Thorpe's Dictionary of Applied Chemistry, Vol. 1, (1921), pp. 171-173. It is there stated that the product of the china clay, "alum cake," which is said to average 12 to 13 per cent. soluble alumina and 0·12 to 0·22 per cent. ferric oxide, contains the whole of the silica, iron, and other impurities present in the clay and that 60 per cent. of the alumina present in the clay is converted into sulphate. "Bauxite" has the advantage over china clay in that it is more readily soluble in sulphuric acid, needs no preliminary calcination and contains a larger percentage of alumina. It is subject to one drawback in that the average percentage of ferric oxide in the least ferruginous bauxites is comparatively large, as is seen in the accompanying analyses :—

	CHINA CLAY.		BAUXITE.		
	1. Belgaum, India.	2. St. Austell, Cornwall.	3 Co. Autrim, Ireland.	4. Dept. de Var France.	5. Chota Nagpur, India.
SiO_2 .	44·00	46·20	13·0	15·8	1·32
TiO_2 . .	..	..	6·0	1·20	6·50
Al_2O_3 . .	41·30	41·10	42·00	66·50	60·49
Fe_2O_3 . .	0·50	0·20	2·00	2·10	2·01
H_2O (combined)	11·90	12·50	21·00	15·20	28·79

The commercial products known as "alumino-ferric" and "alferite" which are prepared by digesting crude bauxite with sulphuric acid are used in the preparation of all but the finest papers, in the precipitation of sewage and refuse liquids, and in the clarification and decolorisation of water supplies. The pure aluminium sulphate is only made from pure alumina, and this substance is obtained directly from bauxite by the so-called Bayer Process.

Amber.

[E. H. PASCOE.]

Production.

The production of amber during the five years 1919 to 1923 is shown in Table 98. The average annual production was 31·44 cwts. valued at Rs. 352 per cwt., compared with 18·4 cwts. valued at Rs. 228 per cwt. during the five years 1914 to 1918. The right to collect a 5 per cent. *ad valorem* royalty on amber in the Myitkyina and Upper Chindwin districts is farmed out with the jadeite royalties (see page 169).

TABLE 98.—*Production of Amber in the Myitkyina District, Upper Burma.*

Years.	Quantity.	Value.	
	Cwts.	Rs.	£
1919	7·4	*6,160*	536(*a*)
1920	72·0	*16,660*	1,666(*b*)
1921	26·3	*16,840*	1,123(*c*)
1922	3·6	*1,960*	131(*c*)
1923	47·9	*13,720*	915(*c*)
Average . .	31·44	*11,068*	874

(*a*) £1 = Rs 11 5 (*b*) £1 = Rs 10 (*c*) £1 = Rs. 15.

Occurrence.

The Burmese diggings for amber are situated in the Hukong valley in the Nangotaimaw hills between Mainghkwan and Lalaung villages in about latitude 26° 20′ and longitude 96° 30′. The substance is found in pits from 20 to 40 feet deep, in blue clay of probable Miocene age; these pits are dug in a haphazard way and are occasionally joined up by underground connections. Fragments of amber have been similarly found in association with beds of this age in other parts of Burma, for example at Mantha in the Shwebo district, and are said to have been met with on the oil-field of Yenangyat in the Pakokku district. Where definitely known it is usually associated with

lignite or coal. Most of the material is brought from the Hukong valley in Upper Burma to Mandalay, where beads for rosaries, *nadaungs* (ear-cylinders), and other trinkets for personal ornament are made from the transparent varieties.

Chemical and physical properties.

The amber of Burma differs in chemical and physical characters from previously known varieties and the name *burmite* has been consequently suggested for it as a specific distinction.[1] The well-known amber of Eastern Prussia contains from 2½ to 6 per cent. of succinic acid and is known to the mineralogist as *succinite.* The Burmese amber is harder and denser, and it is doubtful whether it contains any succinic acid, though the products of its dry distillation include formic acid and pyrogallol; its ultimate chemical composition has been determined to be as follows:—

Carbon	80·05
Hydrogen	11·50
Oxygen	8·43
Sulphur	0·02
	100·00

The specific gravity of burmite varies between 1·030 and 1·095. It is distinguished from many other amber-like resins by its superior hardness and greater toughness, which render it fit for carving and turning. It varies in colour from pale yellow to dull brown, and possesses a peculiar fluorescence, like that which distinguishes the Sicilian variety *simetite.*

Apart from the occurrence of a large percentage of discoloured opaque pieces, many of the large fragments obtained are damaged by cracks filled in with calcite; otherwise there appears to be a large quantity of material which might be put on the market with profit.

Antimony.

[E. H. PASCOE.]

Shigri.

A mining lease to work the well-known antimony-ores (stibnite with oxides) near the Shigri glacier in Lahaul was granted in 1904 to Colonel R. H. F. Rennick. The stibnite lodes are associated with gneissose

[1] O. Helm; *Rec. Geol. Surv. Ind.*, XXV, p. 180 (1892), and XXVI, p. 61 (1893).

granite and are situated at an elevation of 13,500 feet; to reach the locality it is necessary to cross the Hamta Pass (14,500 feet). Work is possible for two or three months only in the year and labour and supplies have to be brought from the nearest village, 3½ marches away. In spite of these difficulties, however, Colonel Rennick succeeded in 1905 in shipping over 400 maunds (15 tons) of stibnite to England, making use of migratory flocks of sheep as transport. Since then further quantities have been quarried and his deposits are thought to be extensive enough to yield 200 to 400 maunds of stibnite a year, but no further shipments were made on account of the low price of star regulus. The stibnite has yielded 6 dwts. of gold per ton. Galena and blende are also found in the same locality, the former being argentiferous. No production from this area has been reported during the five years under consideration.

Southern Shan States.

The existence of an antimony deposit of considerable size in the Mong Hsu State, one of the Southern Shan States, is indicated by the return, amongst the mineral statistics for Burma for 1908, of an output, under a mining lease held by Mr. W. R. Hillier of Lashio, of 1,000 tons of antimony-ore, of which 11 tons were sent to London for assay and valuation. The output from the Southern Shan States in the following year was recorded as 2½ tons, since when there have been no returns. Further details regarding these deposits have been published in the Records of this department by Mr. H. C. Jones, who concludes that none of them appears to be large or of much economic value.[1]

Other localities.

In 1905, stibnite with cervantite was found in the Northern Shan States.[2] The lead slags at Shekran in Jhalawan, Baluchistan, have been found to be antimonial.[3] The tetrahedrite found in the Sleemanabad copper lodes [4] is also highly antimonial. A few pounds of antimony ore were recorded from the Jhelum district, Punjab, for the years 1914 to 1918, but no output has been reported during the quinquennium under consideration. Stibnite has for many years been known to exist in the Amherst district of Burma. In response to a considerable demand for antimony

[1] *Rec. Geol. Surv. Ind.*, LIII, pp. 44—50 (1921).
[2] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 234 (1906).
[3] G. H. Tipper, *ibid*, XXXV, p. 51 (1907).
[4] L. L. Fermor, *ibid*, XXXIII, p. 62 (1906).

during the year 1916, this supply, derived from two or three localities, was increased to 1,000 tons, but fell to 105 tons in 1917 and to *nil* in 1918. Dr. A. M. Heron recently investigated these occurrences and concluded that, at the price of antimony obtaining in 1921, some of them could be profitably exploited; a description of his work has been published in the Records of this department.[1] Mysore responded to the same stimulus but the production fell to 0·1 ton in 1918. During the five years, 1919-1923, the only recorded outputs of antimony ore were 6·4 tons valued at Rs. 2,000 in 1919, and 1·6 tons valued at Rs. 250 in 1921, both from the Southern Shan States of Burma.

Uses.

Antimony is used chiefly for hardening alloys, for match manufacture and the vulcanising of rubber in the form of sulphide, and for calico-dyeing and calico-printing in the form of tartrate and oxalate.

Arsenic.

[E. H. PASCOE.]

Occurrence.

The chief indigenous source of arsenic is the orpiment mines of Chitral, where the mineral is exploited by the Mehtar of that country. Mr. G. H. Tipper, who has recently carried out a survey of the State, reports that the orpiment is in most cases accompanied by realgar and fluorspar, and the mines, judging from the size and extent of the workings, are of considerable age. The six principal areas with their heights above sea-level are:—(*i*) Mirgasht Gol (11,000 feet); (*ii*) Aligot (13,000 feet); (*iii*) Londku (11,000 feet); (*iv*) Wizmich (16,000 feet); (*v*) Moghono zom (15,000 feet); Stack (14,000 feet). The last four deposits are on the same line of strike. The arsenic ore occurs close to a band of basic intrusive rock in calcareous shales associated with marble. The output of the mines fell off during

[1] *Rec. Geol. Surv. Ind.*, LIII, p. 34 (1921).

the earlier years of the century and was less than 10 tons in 1905-06. No returns are available for recent years, although the industry is still carried on. The difficulties in working the present mines include the inaccessibility of the area, the inclemency of the weather, the unscientific lay-out of the mines and the lack of adequate ventilation. Mr. Tipper considers that there are good prospects of discovering fresh untouched deposits in Chitral.

A seam of arsenopyrite 1 foot thick, of which about two-thirds consist of ore, is recorded from the northern flank of Sampthar Hill near Darjeeling. A small outcrop of the same mineral is known to occur near Barali in the Bhutna valley, Kashmir. The occurrence of orpiment near Munsiari in Kumaon has long been known,[1] small quantities of this mineral and of realgar, the other sulphide, being sold in the bazars of northern India; but it was not till 1906, when Messrs. G. de P. Cotter and J. Coggin Brown found scattered fragments of both minerals lying on the moraine material of the Shankalpa glacier, that any precise locality was ascertained. The ore was not found *in situ*, but had probably come from the hill-face immediately above.[2] Large lumps of leucopyrite, an arsenide of iron, have been found in the pegmatites of the mica-mining field near Gawan in the Hazaribagh district,[3] and other arsenides have been found associated with pyritous lodes in various places, but no attempt has been made to recover arsenic from these occurrences.

Details with regard to the production and use of Indian arsenic are not available, but there has been a considerable trade in both the Indian and foreign commodity, presumably in the form of white arsenic.

Exports and imports.

Table 99 shows the extent of this trade for the period under review, but does not include the trade in orpiment, which is shown separately. By comparison with the corresponding tables of previous reviews it will be seen that the annual imports of foreign arsenic remained remarkably constant up to the year 1913 (2,346 cwts. for 1898-1903; 2,370 cwts. for 1904-08; and 2,596 cwts. for 1909-13). During 1914-18 the figure fell to 1,558 cwts.; during the five years under review it amounted to 1,568 cwts. valued at Rs. 96,012.

[1] A. W. Lawder, *Rec. Geol. Surv. Ind.*, II, p. 88 (1869).
[2] *Ibid*, XXXVI, p. 129 (1908)
[3] T. H. Holland, *Mem. Geol. Surv. Ind.*, XXXIV, p. 51 (1902).

TABLE 99.—*Average annual Exports and Imports of Arsenic (excepting Orpiment) for the years 1919-20 to 1923-24.*

	Quantity.	*Value.*
	Cwts.	Rs.
Exports of Indian Arsenic (except Orpiment)—		
To Bahrein Islands	33	*1,448*
,, Straits Settlements . . .	72	*2,869*
,, Other countries	13	*727*
TOTAL . .	118	*5,044*
Imports of Foreign Arsenic (except Orpiment)—		
From United Kingdom . . .	547	*26,324*
,, China (with Hong-kong) . .	656	*49,239*
,, Straits Settlements (including Labuan).	66	*3,399*
,, Other countries	299	*17,050*
TOTAL .	1,568	*96,012*
Re export of Foreign Arsenic (except Orpiment)	210	*9,028*

Chinese orpiment.

Orpiment, the yellow sulphide of arsenic, is largely imported into Burma from Western China for use mainly as a pigment. During the five years 1919-20 to 1923-24 the average annual imports across this frontier amounted to 8,864 cwts. valued at Rs. 2,15,464 or Rs. 24·3 per cwt. (see Table 100) as compared with 3,731 cwts. valued at Rs. 77,505 or Rs. 20·8 per cwt. during the five years 1914-15 to 1918-19.

The mineral is used as a pigment in the manufacture of Indian ornamental lac-wares and the Burmese lacquer-work ; in the latter the favourite greens of the Pagan workers are produced by mixtures of indigo and orpiment, and the so-called gold-lacquer of Prome by powdered orpiment and gum. Orpiment is used also for the designs on the Afridi wax-cloths.

TABLE 100.—*Imports of Orpiment from Western China.*

Year.	Quantity.	*Value.*	Value per cwt.
	Cwts.	Rs.	Rs.
1919-20	7,926	*1,85,547*	23·4
1920-21	8,797	*2,25,134*	25·6
1921-22	7,366	*1,82,114*	24·7
1922-23	10,808	*2,65,044*	24·5
1923-24	9,421	*2,19,482*	23·3
Average . .	8,864	*2,15,464*	24·3

Asbestos.

[E. H. PASCOE.]

Attempts to develop asbestos in India have not yet met with any marked success on account of the inferior quality of the material in the deposits hitherto discovered. In 1910, 3 tons of asbestos valued at £6 were extracted in the Bhandara district, Central Provinces, presumably during prospecting operations; this source was recently given a fresh trial, yielding 7 tons in 1917 and 13 tons in 1918. The past five years have shown very little improvement; 9 tons were extracted in 1919 and 14 tons in 1922. In 1913 a small amount of work was carried out in the Hassan district, Mysore, where asbestos of fair quality is found in veins traversing actinolite schist, and the supply rose to 344 tons in 1918; this source has continued to yield amounts of this order every year since and in 1920 produced as much as 1,711 tons valued at Rs. 68,440. In 1920 and 1921 small outputs were recorded from the Bangalore district.

Several fresh occurrences were discovered during the period 1909-1913, of which two appeared to be of some size. One of these, near Dev Mori in Idar State, Bombay Presidency[1] contains a con-

[1] C. S. Middlemiss, *Rec. Geol. Surv. Ind.*, XLII, pp. 53, 73 (1912).

siderable amount of amphibole-asbestos in large rod-like masses yielding long-staple material up to 8 inches; hopes were at first entertained of this product but unfortunately it has proved to be too brittle. The other occurrence is in the Seraikela State, Singhbhum, the asbestos being of the amphibole variety, obtainable in long columnar masses, the more superficial portions suffering from the same defect of brittleness; recently, however, it has been found that the quality improves with depth, and hopes are entertained that this may prove to be the case in other localities also. Increasing uses are being found for asbestos, as frequent enquiries indicate, so that there is every inducement for the exploitation of utilizable fibre.

TABLE 101.—*Production of Asbestos during the years 1919 to 1923.*

	1919.		1920.		1921.		1922.		1923.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
Bihar & Orissa— Seraikela State	..	..	..	..	11·5	*1,100*	...	...	...	.
Central Provinces—										
Bhandara .	9	*1,396*	..	..	..	..	14	*1,400*	..	..
Mysore—										
Bangalore .	..	..	107	*4,280*	67	*2,680*	..	..	..	..
Hassan . . .	379	*15,160*	1,711	*68,440*	237	*9,480*	228	*9,120*	247	*9,880*
TOTAL	388	*16,556*	1,818	*72,720*	315·5	*13,260*	242	*10,520*	247	*9,880*
Total value in sterling .		*£1,440 (£1= Rs. 11·5)*		*£7,272 (£1= Rs.10)*		*£884 (£1= Rs. 15)*		*701 (£1= Rs. 15)*		*£659 (£1= Rs. 15)*

Barytes.

[E. H. PASCOE.]

Barytes, or heavy-spar, has many applications in the arts, such as giving weight to paper and body to paints, and as a flux in metallurgy (particularly for ferro-manganese). It seems to be widely distributed throughout the Indian Empire, but has only in recent

years been seriously exploited. At Sleemanabad in the Jubbulpore district, one of the copper lodes is rich in barytes, which, however, is said to be of poor quality.[1] It occurs in considerable quantities at Balpalpalle and other localities near Betamcharla in the Karnul district, Madras, and has been quarried for use in paint works in this country. The production during the period 1919 to 1923 is given below:—

Years.	Quantity.	Value.	
	Tons.	Rs.	£
1919	2,590	*15,616*	1,358 (*a*)
1920	678	*15,528*	1,553 (*b*)
1921	1,457	*47,603*	3,173 (*c*)
1922	1,712	*41,500*	2,767 (*c*)
1923	1,603	*22,749*	1,517 (*c*)
TOTAL .	8,070	*1,42,995*	10,368

(*a*) £1 = Rs. 11·5. (*b*) £1 = Rs. 10. (*c*) £1 = Rs. 15.

Amongst other known occurrences of barytes in India, the following may be mentioned:—

(1) Narravada, Nellore district, Madras: barytes veins in mica schist, into which they pass in places.[2]

(2) Bawdwin silver-lead mines, Northern Shan States: in considerable quantity at one spot.[3]

(3) Taung-gaung, Mandalay district, Burma: a bed of barytes 6 to 7 feet thick.[4]

(4) Kelat and Las Bela States, Baluchistan: fairly abundant in the Belemnite shales; the most accessible locality is Pabni Chauki, about two days' march from Karachi.[5]

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 62 (1906).
[2] H. C. Jones, *ibid*, XXXVI, p. 233 (1908).
[3] T. D. LaTouche and J. C. Brown, *ibid.*, XXXVII, p. 255 (1909).
[4] H. H. Hayden, MS. notes (1896).
[5] G. H. Tipper, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 214 (1909).

realise the importance of strict attention to quality. Efforts have been made to float companies for the reduction of aluminium in India without due appreciation of the situation. It is insufficiently realized that in most cases in India electric power can only be obtained by the construction of elaborate and very expensive storage dams, that all the cryolite must be imported, and that the purification of the bauxite to alumina and the preparation of the high-grade carbon electrodes involves the working of specialised processes on a big scale. The aluminium production of the world is in the hands of only four great groups of producers, the output capacity of whose works are larger than the present demands which they supply. These monopolistic firms have assured sources of supply as regards their raw materials, bauxite and cryolite. There are probably no cheaper sites for hydro-electric power than those they use. In addition to purifying their bauxite in alumina works owned by themselves, they possess factories for the manufacture of carbon electrodes, foundries for making alloys and castings, rolling mills for the output of sheets, circles, wire, etc. Finally they have excellent shipping facilities and their markets are not only established but cultivated. In the present state of the aluminium market such powerful organisations could not allow a new company of any pretentions to come into being. Such a venture might be successful if backed by overwhelming advantages, *e g.*, cheap electric power, good quality bauxite in favourably located occurrences, assured supplies of cryolite, and a highly skilled staff for operating the alumina plant and in making carbon electrodes. But if the Indian demand for aluminium be considered insufficient to justify this outlay and the Indian producer be unable to face competition, the general question of developing the bauxite resources of India, apart from the establishment of an aluminium industry, is one well worthy of attention. However, it is necessary that the requirements of the markets be studied and understood by the vendors of bauxite.

At the present time the world's production of bauxite is used in the following approximate proportions in several industries :—

	per cent.
For aluminium after conversion to alumina	60
For the manufacture of chemicals	20
In the production of abrasives	10
For the preparation of refractories	8
Used in the manufacture of bauxite cement, for the purification of kerosene, and for other purposes excluding building stone	3

If the world's output of bauxite be taken roughly as 500,000 tons annually, it is evident that the quantities absorbed in the minor manufacturing industries are attractively large.

Classification.

The two main classes of ore are (1) the Mediterranean type and (2) the Tertiary type. Under the former class are included the bauxites of Spain, France, Italy, Yugo-Slavia and Rumania—types which seldom contain more than 14 per cent. of combined water and indicate a certain degree of dehydration. The latter class includes most of the bauxites of America, Africa, India and Australia; these deposits appear to be of a geologically younger type and average a combined water content of from 22 to 30 per cent. with a somewhat lower alumina content (54 per cent.) than the Mediterranean type.

For commercial purposes it is convenient to classify bauxites into the following varieties:—

(*a*) *Normal Bauxite.* Fair quality with 55 to 60 per cent. alumina, and high-grade ore with over 60 per cent. of alumina. Total impurities not to exceed 20 per cent., excluding the combined water content. The chief impurities, ferric oxide, silica and titania, each not to exceed 5 per cent.

(*b*) *White or siliceous bauxite.* To have upwards of 55 per cent. alumina and not more than 20 per cent. impurities excluding the combined water. Silica from over 5 to about 20 per cent. Ferric oxide less than 5 per cent. Titania up to 5 per cent. This class of ore is most frequently used for chemical purposes or the preparation of alum and other aluminium salts.

(*c*) *Titaniferous bauxite.* The alumina to average 55 per cent. and the total impurities excluding combined water not to exceed 25 per cent. Titania above 7 per cent. Silica less than 5 per cent. Ferric oxide not to exceed 10 per cent. These bauxites are rare except in India but have a great future before them owing to the valuable nature of the titaniferous slime which can be obtained as a by-product when the ore is purified by the Bayer process.

(*d*) *Red or ferruginous bauxite.* Alumina content to be upward of 52 per cent. Total impurities not to exceed 25 per cent. Ferric oxide between 10 and 25 per cent. Silica to be less than 5 per cent. Titania normally less than 5 per cent. This variety of bauxite is most commonly used by aluminium reduction companies.[1]

Quarrying and mining.

In France the bauxite occurs interbedded with beds of Upper Cretaceous age. The outcrops can frequently be quarried by means of open pits but when the bauxite zone dips away to appreciable depths the material has to be mined in the same way as coal or other bedded deposits. Much of the bauxite in the Département de Var (France) is mined like gently inclined coal seams. Occasionally the bauxite bed is steeply inclined and necessitates the procedure in vogue in metal mines; a good deal is quarried in a normal manner. The bauxite of County Antrim (Ireland) is worked in the same way as the French ore. In Ireland the bauxite occurs as an aluminous laterite interbedded with the basaltic lavas of Ulster. The bauxite of Italy, Dalmatia, etc., and the Balkan area in general has been won by simple quarrying by hand.

In the United States of America the Arkansas bauxite, consisting of a gently inclined ore bed about 11 feet thick which is overlain by loose sandy clay, is quarried. In Georgia, Alabama and Tennessee the ore occurs in irregular pockets which involve working by open pits; some ores require the use of explosives.

In British Guiana the bauxite at present being worked is exposed on the surface of the ground and merely requires digging out. The same is true for the bauxite occurrences of West Africa and India. In the latter country the greater number of bauxite deposits occur as segregations in the laterite which cap flat-topped hills and plateaux. These occurrences can be worked and kept free of water with little difficulty. There are localities in India as in other countries, where bauxite occurs under loose material in low ground or interbedded with more massive strata. The removal of overburden or the de-watering of workings naturally increases the cost of the raw material but these factors may be offset by the favourable location of the deposit with regard to a railway or waterway.

[1]*The Mining Journal* for Dec. 30, 1922, p. 986.

It has previously been shown that raw bauxite contains from 10 to over 30 per cent. of combined water. As most bauxites require transportation over considerable distances to the place where it is utilized, it has become customary, particularly in the United States, for large producing companies to get rid of some, or all, of the combined water by drying first. In Arkansas the ore from the mine is crushed or disintegrated and eventually roasted in rotary kilns. These kilns were once fired mostly by producer gas, but they have been converted to burn pulverized coal exclusively. The temperature used is probably about 1,100° F. (roughly 600° C.) and the mechanically held moisture is reduced from half a per cent. to 1 per cent.[1] A very similar procedure is employed in dealing with the bauxite of British Guiana.

Calcination.

The process at present commonly employed, both in Europe and America, for the manufacture of alumina from bauxite is known as the Bayer process. (See Aluminium, by G. Mortimer, 1919, pp. 22-23). The whole plant is elaborate and expensive. There are, as may be imagined, many precautions to be observed to prevent waste, and great experience is necessary for the successful working of the plant. Very little of the caustic soda used is lost if the bauxite is properly corrected, and the ferric oxide sludge obtained in the first set of filters could be used as an iron ore or as paint material.

Manufacture of alumina and aluminium.

Almost all the aluminium of commerce is produced in some simple form of electric furnace such as the Hall Heroult, using 8,000 to 20,000 ampères at a low voltage (5 to 8 volts). In practice there are many pit-falls, and great care is necessary in the control and management of the plant. (See Aluminium, by G. Mortimer. 1919, pp. 29-40). The consumption of the carbon electrodes constitutes a large part of the expenditure, as they are made of the purest carbon (petroleum coke with tar for a binding material). The enormous current used necessitates cheap electrical power as a *sine qua non*, and a large-scale production is almost certainly more economical than a small output. The manufacture of cheap electrodes of good quality requires consideration, as the impurities in the electrode, silica, ferric oxide, etc., go into the metal and cannot be subsequently removed. Most of the cryolite used comes from mines in Greenland, but an artificial cryolite is now available. The market price for

[1] *Engineering and Mining Journal Press*, Nov. 4, 1922, p. 807.

cryolite in the United Kingdom is £56 per ton, and this material would have to be imported into India.

For chemical purposes.

Under the article dealing with Alum and Aluminous Sulphates mention was made of the use of bauxite for the preparation of "alumino-ferric" and "alferite", *i.e.*, crude aluminium sulphate. Attention was drawn to the fact that pure aluminium sulphate was only made from pure aluminium hydroxide. These two pure substances, aluminium sulphate and hydroxide, are used as the basis ot manufacture in preparing other aluminium salts, *e.g.*, aluminium chloride. Aluminium hydroxide possesses a powerful affinity for many organic substances, and enters into association with a large number of colouring matters, precipitating them completely as *lakes*. On this property depends the use of alum mordants. They precipitate the hydroxide upon the fibre of the goods to be dyed and this constitutes the fixing agent, or *mordant*, which retains the colour. Aluminium chloride(anhydrous) possesses great technical advantages in petroleum refining. It is largely used in the United States of America to convert all unsaturated into saturated compounds, thus converting unstable gasoline and lubricating oils (of asphaltic base) into excellent staple products of good colour and odour practically equal to paraffin-base products. It is expensive, however, and this factor prevents its use in oil purification on a very large scale.

For petroleum purification.

It has been known for many years that fuller's earth is capable of exercising a selective action on petroleum by retaining the unsaturated hydro-carbon and sulphur compounds which were in the oil. This remarkable property was utilized in oil refineries in the United States and other countries and the theoretical aspects of the phenomenon have been ably discussed in numerous papers. (See *Proc. Amer. Phil. Soc.*, 36, No. 154, 1897 ; Bulletin 315, *U. S. Geol. Surv.* 1907 ; Richardson and Wallace in *Journ. Soc. Chem. Ind.* for March 1912 ; and numerous other papers.) Investigation has shown that colloids such as alumina, bauxite, fuller's earth, etc. when freshly ignited (about 500° C), acquire the curious property of actively attaching to themselves (on their surfaces), by absorption, other colloids and certain reactive substances. Colouring matter and sulphur compounds in particular are readily absorbed when kerosene is filtered through freshly treated bauxite.

This decolorization and de-sulphurization of mineral oil by fuller's earth, bauxite, etc. is said to be produced by physico-chemical action relating to surface tension. No reagent is necessary and no chemical

interaction results although a slight rise of temperature has been noticed. Kerosene when filtered through graded bauxite 30 to 60 mesh, becomes water clear and, for practical purposes, free of sulphur. In process of time the bauxite in a filter becomes less active but it can be rendered effective again by re-heating. Thus it appears that except for handling for re-heating and sieving there would be no loss of the bauxite, which can be used over and over again. Bauxite filters are now being installed in all modern oil refineries for the purification of kerosene. According to A. E. Dunstan (*The Petroleum Industry* 1922, p. 182) Messrs. the Hall Motor Fuel Company have in recent years carried out this process in a slightly different way. By passing the vapour of petroleum over heated bauxite "cracked" spirit, a most difficult substance to refine, is capable of simple and easy refining without any chemical treatment at all, and with the minimum of loss.

Considerable attention has been attracted to the fact that all kinds of bauxites are not equally efficient in the purification of kerosene. Also, much experimental work is in progress to discover why the most efficient kind of bauxite for kerosene purification is not equally effective in desulphurising petrol, and the reason of its failure when used for the purification of lubricating oil. Very little information is available regarding the results obtained in the recent investigations regarding the use of bauxite for the desulphurization, etc. of all the petroleum distillates from light spirit to the stiff wax. The subject of the use of bauxite for petroleum purification has been carefully investigated by the Research Department of the Anglo Persian Oil Company, and as a result two useful papers, "Bauxite as a refining Agent for Petroleum Distillation" by A. E. Dunstan and others and "Technical Use of Bauxite in connection with Petroleum Refining" by A. M. O'Brien, have been published (see *Jour. Soc. Chem. Indus.*, vol. 43, No. 24, 1924, pp. 179T-189T). Until a bauxite is actually tested it appears difficult to say how efficient it may prove for the purification of kerosene. The chemical analysis gives practically no clue to its value for this purpose. So far, the Indian type of bauxite (with high combined water) appears to have proved most suitable and it is thought that this is due to the micro-cellular structure which must result when this bauxite is ignited preparatory to its use in the kerosene filter.

The demand for bauxite for oil purification becomes larger year by year and would be very considerable if bauxite was, by suitable thermal treatment, made capable of purifying all petroleum distillates as efficiently as it treats kerosene. The waste, chiefly as dust, in crushing,

heating, sieving, re-heating, etc. although not large at first, steadily accumulates so that, perhaps some economy could be effected by collecting the dust and marketing it as "bauxite dross."

Decolorization of sugar.

Bauxite has also been found suitable for the decolorization of sugar and other hydro-carbon solutions so that a large field for research is open, the successful exploitation of which would create a further demand for bauxite. Colloidal alumina is thought to be more effective than either bauxite or fuller's earth for the desulphurization and decolorization of mineral oils, etc. so that it is possible that economy might be effected by preparing cheap pure colloidal alumina from bauxite.

Bauxite cements.

It has been known for several years that Portland cement deteriorates rapidly when exposed to waters containing sulphates. The failure is said to be due to the formation of sulpho-aluminate of lime. This substance combines with water and undergoes crystallisation with a large increase in volume. Experiments by the United States Bureau of Standards and by other investigators, particularly M. Bied in France, led to the preparation of high-alumina cements. These cements are essentially calcium aluminates low in silica. They have been manufactured by fusing together bauxite, coke and limestone, with occasionally slag or schist of suitable composition, in a small blast (cupola) or electric furnace. The fused product is poured, cooled and ground to make the finished product (see '*Engineering*' for August 11th, 1922, page 180). The prepared product has an approximate composition of 40 per cent. alumina, 35 to 50 per cent. lime, 8 to 12 per cent. silica and from 2 to 14 per cent. ferric oxide. No special quality of bauxite appears to be necessary, though the resulting cements are not equally efficient. The manufactured high-alumina cements are sold as "fused cements," "Lafarge cement," "ciment electrique," "ciment fondu," etc. "Ciment fondu" is being manufactured by the "Société Anonyme des Chaux et Ciments de Lefarge et du Tiel," who have works at Tiel and Montiers (Savoie). "Ciment électrique" is reported to be available from the "Bureau d'Organization Economique" and it is manufactured by the "Société des Produits Chimiques d'Alais, Forges et Camargue," at their Argentiere works.

A considerable amount of attention was given to these cements during the Great War. High-alumina cements, because of their quick-setting properties and the fast development of their full strength

were used in the construction of heavy gun emplacements, "pill-boxes," etc. However, for various reasons now known, these high-alumina cements did not fulfill the results then expected of them; they set too quickly and were rapidly affected to their disadvantage if contaminated with lime or Portland cement before or during use. Since the war they have been used, with these precautions, and have proved of great value in difficult cases. Some of these uses have been for concrete piles, masonry exposed to sea-water, tunnels through strata contaminated with sulphates, in *caissons*, etc. The advantages this material possesses over Portland cement are its immunity from deterioration when exposed to sea-water or to waters or soils containing sulphate salts, and its rapidity of setting and attaining full strength. It is stated that in typical tests the tensile and compressive strengths obtained by high-alumina cements in a few hours were greater than those of Portland cement after several weeks. The following figures (quoted from '*Engineering*' of August 11th, 1922, page 180) are of interest: "Ciment fondu," tensile strength 59 kilograms after 48 hours and 71 kilograms after 28 days as against 55 kilograms in 28 days for Portland cement. The compression results were 687 kilograms per square centimetre in 48 hours and 950 kilograms in 28 days for "ciment fondu" as against 612 kilograms in 28 days for Portland cement.

The value of these physical properties will be at once evident to the civil engineer, and, although the present cost of the material is nearly double that of Portland cement, it must appeal to him as being the most suitable substance in every way for particular purposes. The high cost is largely due to the expense involved in fusing the raw materials. It is claimed that careful calcination is sufficient but so far the best results have been obtained by fusing the raw material. The commercial preparation of this type of cement is still in its infancy and much is expected from the investigation now in progress.

Bauxite for abrasive purposes.

A substance which possesses the hardness of natural crystalline corundum could easily be marketed if it were possible to produce it cheaply and utilise it for the manufacture of grinding wheels, rubbing bricks, hone stones, polishing powders, etc. The best grades of natural pure corundum average from 95 to 99 per cent. alumina with small percentages of silica and ferric oxide as impurities. A lower grade of corundum consisting of a finely intergrown mixture of corundum and

magnetite crystals is the substance known as natural emery. Large occurrences of corundum and emery are not common and in consequence of the increasing demand for such material for abrasive purposes an important industry for the manufacture of artificial corundum and emery has developed. In the majority of these new works the raw material used is calcined bauxite. This ore is fused in an electric furnace of the arc type and the melt allowed to cool sufficiently slowly to become crystalline when solid. The solid "pig" is then removed from the furnace, broken up and crushed. mixed with a suitable binder and made into the various types of grinders' tools, wheels, bricks, etc., required and these raw manufactured articles are burnt or baked in a kiln before being ready for the market.

There are several artificially prepared types of corundum and emery goods now available which have been made from bauxite in the general manner described above. It is obvious that the quality of the abrasive will depend on the quality of the bauxite used in its preparation. High-grade bauxite with little or no silica and no ferric oxide would give very high-grade corundum, whereas a ferruginous bauxite would invariably produce emery. On the market these artificially prepared corundum and emery goods bear the trade name of the manufacturers: thus 'aloxite,' which contains upwards of 94 per cent. alumina, is made by the Carborundum Company, who have works at Niagara Falls and, to be near the French bauxite, at Sarancolin in the Hautes Pyrénées; 'alundum' is a very similar material and is prepared by the Norton Company of Chippawa in Canada and sold by them in two grades, "white" and "ordinary;" 'boro-carbone,' is practically only another quality of aloxite and is also manufacutured by the Carborundum Company in France and at the Niagara Falls but its sale is controlled by the Abrasive Company of Philadelphia, Pennsylvania.[1]

Bauxite refractories.

Owing to the large percentages of combined water in most bauxites it is necessary to calcine thoroughly the raw material before moulding it into bricks and other articles. A binding material such as fireclay is normally used in the manufacture of bauxite refractory goods. The finished ware, although capable of withstanding temperatures up to 1800° C., have the objectionable properties of cracking with changes of tem-

[1] F. B. Jacobs, "Abrasives and Abrasive Wheels," 1919, pages 53—62

perature and shrinking as long as they are exposed to high temperatures. The bauxite linings of furnaces become very hard after heating and are consequently of value in rotary cement kilns where the lining is subject to considerable attrition by the gravitating charge. The quality of the bauxite used in the manufacture of various kinds of goods very greatly affects the melting point and slag-resisting power of the article. Ferruginous bauxites melt at about 1600° C, or less. Siliceous bauxites are liable to rapid corrosion by basic slags. A bauxite high in alumina with very low percentages of farric oxide or silica makes an exceedingly valuable basic refractory. If sufficiently calcined it becomes as hard as emery and is not subject to serious expansion when exposed to high temperatures. However. the high temperature of calcination makes this bauxite refractory somewhat expensive for general purposes.

" High alumina refractories[1] are arbitrarily distinguished from other refractories containing alumina, by an alumina content of at least 58 per cent. Such refractories are ordinarily made from bauxite or bauxite and high-alumina clays (bauxitic clays, diaspore clays and similar material). Ordinary bauxite bricks are made by mixing calcined bauxite or high-alumina clay with a bonding material such as fireclay, sodium silicate, or lime, shaping by hand or by brick machines, and burning in various types of brick kilns at a high temperature. Another class of bauxite refractories is made by fusing bauxite in an electric furnace and casting the molten material in moulds. The demand for this type of refractories is increasing owing to the ever-growing needs for better refractories. Pure bauxite melts at about 1,820° C. and pure alumina at about 2,050° C., but the lower grades of bauxite brick melt at 1,740° or less. The value of bauxite refractories depends upon their chemical inertness at high temperatures. In basic open-hearth steel practice bauxite brick should contain over 12 per cent. silica.

" Recently high alumina refractories have been made more commonly from diaspore and high-alumina clays than from bauxite."

Bauxite specifications and contracts.

For many years the principal use of bauxite has been for the preparation of alumina and the subsequent reduction of this substance to aluminium. In a subsidiary way bauxite of a certain quality has been utilised in the chemical industry, and some bauxite

[1] *Eng. and Min. Jour. Press*, Vol. 114, No. 19, Nov. 4th, 1922, p. 809.

has been absorbed in the production of *alundum* and other purposes. The chief users have usually possesed or leased bauxite properties so that there has been little or no buying and selling of bauxite in the open market. During the last decade, however, a considerable degree of attention has been devoted to the development of bauxite properties which are not under the control of monopolistic consumers. This has come about by the increasing demand for bauxite. This is the result not only of the expansion of the aluminium industry but of the use of bauxite for the purification of petroleum and other oils; a new field has opened with the successful manufacture of so-called bauxite (high-alumina) cements. (See 'The Mining Journal' of 30th December 1922.)

Aluminium reduction companies will seldom accept bauxite with more than 5 per cent. silica although they have been known to take delivery of ore with as much as 20 per cent. ferric oxide. Chemical works do not refuse bauxite containing 10 per cent. of silica if the alumina content is high and the ferric oxide percentage is below 3 per cent. They seldom accept ore with more than 5 per cent. ferric oxide. Manufacturers of abrasives while demanding the best grades of normal bauxite often utilize ore with less than 50 per cent. alumina and more than 10 per cent. silica or 15 per cent. ferric oxide. Makers of furnace refractories stipulate that the ferric oxide content must be low but may accept bauxite with as much as 25 per cent. silica. In some cases they prefer to use a material so rich in silica that it can scarcely be called a bauxite. Investigators in oil refineries do not yet know, with any exactness, the type of bauxite most suited to their use. Certain normal Indian ores have been found to de-sulphurize and de-colourize petroleum very effectively but have not been equally efficient with petrol or heavy oils. The purification of petroleum and other oils is evidently effected by the colloidal properties of the bauxite rather than by chemical action; in consequence of this it is at present impossible to judge the value of a bauxite for this purpose on its chemical composition alone. Experiments in the production of high-alumina cements ("ciment fondu," etc.), although showing the commercial importance of the finished product have not yet proved than one type of ore is more particularly desirable than another provided the alumina content is high.

All consumers would probably be willing to accept somewhat inferior qualities of ore at advantageous prices if the composition of the material could be guaranteed within certain agreed narrow

limits. It is the practice of most consumers to calcine partially the raw bauxite before finally grinding it to dust or slime. This calcination, usually performed at a temperature not exceeding 400° C, drives off a considerable amount of the combined water, and gets rid of any organic matter which may be present. It also converts forrous oxide into the more manageable ferric oxide. The alumina content is naturally increased by this calcination, but it is not to be forgotten that the percentage of the impurities is also raised. Raw bauxite is notoriously variable in composition, and in large occurrences it is advisable to sample and analyse the deposit very thoroughly. It is possible, by mixing known qualities of bauxite from various parts of a single large deposit or from more than one deposit, to maintain shipments of uniform quality. In this way, if due attention were paid to the sampling and chemical analysis of bauxite, it is probable that considerable quantities of low grade ore could be mixed with particularly rich material.

Memoirs Gelogical Survey of India, Vol. XLIX, part I, (1923), gives details of the several Indian occurrences of bauxite. The localities in which efforts have been made to work bauxite in India are :—Katni in the Jubbulpore district of the Central Provinces, Belgaum in the Belgaum district and Kapadvanj near Khaira in Gujerat of the Bombay Presidency. Among other areas which have been carefully examined and in which good bauxite is known to occur may be mentioned the following :—Chakar in Jammu, Kashmir; Rupjar in Balaghat, Central Provinces; Radhanagri in Kolhapur State, Bombay Presidency; South Rewa; and Pakripat in the Ranchi district of Bihar and Orissa.

Indian occurrences of bauxite.

At the present time active mining, but on a small scale, is in progress only at Katni and Kapadvanj. In the former case the bauxite is chiefly used in the manufacture of aluminous sulphates in India, whereas the bauxite of Kapadvanj appears to be entirely absorbed for the purification of kerosene.

A general summary of the Indian occurrences of bauxite and its mode of origin by the writer was published in *The Mining Magazine* of February 1922. A similar statement with regard to the aluminium industry as a whole appeared in *The Mining Journal* issues of the 28th October and 4th November, 1922.

Bismuth.

[H. C. JONES.]

The only part of the Indian Empire where bismuth ores have been extracted—and then only on a very small commercial scale—is in the Tenasserim division of Lower Burma. Native bismuth and the sulphide, bismuthinite, occur in the wolfram- and cassiterite-bearing veins of certain localities in the Tavoy district, and also in the adjoining districts of Mergui and Amherst.

Dr. Coggin Brown states[1] "the quantity of the bismuth minerals found in the veins is in itself too insignificant to permit of their profitable extraction on this account alone, and the insignificant amount of bismuth which has been exported from Burma up to the present time has been recovered as a by-product in the sluicing of eluvial deposits for wolfram and tin-stone. As the veins are broken down under the general action of denudation they shed their metallic contents into the surface soil. Deposits formed in this manner on the hill sides are often profitable to work on account of their metallic contents. The bismuth minerals are either hand-picked out of the clean concentrates after sluicing operations, or recovered chemically from the tin ore after magnetic separation. The chemical process is not carried out in India, but is known to have been performed on certain Tavoyan tin ores after their arrival in the United Kingdom. For this reason, the total amount of the small quantity of bismuth ore produced in recent years in Burma is not known, and the only recorded figures are 5 cwt. of ore valued at £163, shipped separately as such. The future output of bismuth ores from India depends entirely on their separation as by-products in the wolfram and tin ore mining industry of Lower Burma. No deposits have as yet been discovered rich enough to exploit for their bismuth contents alone; on the other hand it is certain that small amounts of bismuth minerals are wasted because of the prevalent ignorance of their properties and value. But even when this is allowed for, it must be admitted that the quantites probably obtainable from known deposits in the Tavoy and Mergui districts are comparatively insignificant"

[1] *Bull. Ind. Industries and Labour* No. 6, pp. 23-24, 28.

Borax.

[E. H. PASCOE.]

No undoubted occurrence of borax is known within British Indian territory, and the material exported, which during the last five years has averaged annually 4,622 cwts., of a value of Rs. 1,59,656 (Table 104), is practically all obtained from Tibet and Ladakh, being imported across the frontier into the Punjab and United Provinces. The word *tincal*, by which it is known in the bazars, is in common use on the Punjab frontier in the Himalayan passes, where can be seen herds of goats and sheep coming down in the spring from Tibet, each carrying two small bags of borax or salt to be bartered for Indian and foreign stores.

TABLE 104.—*Exports of Borax by sea from India during the years 1919-20 to 1923-24.*

——	Quantity.		*Value.*	Value per cwt.
	Cwts.	Metric Tons.	Rs.	Rs.
1919-20	4,381	223	*1,41,280*	32·25
1920-21	5,174	263	*1,63,130*	31·53
1921-22	5,463	277	*1,97,837*	36·21
1922-23	3,195	203	*1,21,727*	38·09
1923-24	4,898	249	*1,74,304*	35·59
Average .	*4,622*	*243*	*1,59,656*	*34·75*

In addition to the borax sent by sea to foreign countries. small quantities cross the frontier into Nepal, Kashmir, Kelat, Afghanistan, Tibet and China. Of late years the export trade in borax has very seriously declined. Forty years ago the quantity sent out of India amounted to over 16,000 cwts. a year. valued at £24,000. At that time the greater part of the material exported went to

the United Kingdom (14,134 cwts. in 1883-84), but, with the discovery of large deposits of calcium borate in America, the demand for borax from India ceased, and, under normal conditions, the only large customers are now the Straits Settlements and China.

The amount of borax imported into India across the frontier has averaged (as shown in Table 105) 22,969 cwts. of the value of Rs. 5,70,520 as compared with an average annual figure of 21,723 cwts. valued at Rs. 4,30,800 for the period of the preceding review; whilst the amount imported by sea has averaged (as shown in Table 106) 8,766 cwts. of the value of Rs. 2,52,703 as compared with 7,742 cwts. of the value of Rs. 2,03,130 during the period 1914 to 1919. Adding the land and sea imports, and subtracting the exports, it is seen that there has been a substantial increase in the consumption of borax in India from 24,289[1] cwts. per annum during the period 1914-18 to 27,113 cwts. per annum during the period under review.

TABLE 105.—*Imports of Borax by land during the years 1919-20 to 1923-24.*

YEAR.	Quantity.	*Value.*	Value per cwt.
	Cwts.	Rs.	Rs.
1919-20	21,028	*5,48,501*	26·08
1920-21	18,854	*4,43,699*	23·53
1921-22 . . .	22,219	*4,97,965*	22·41
1922-23	21,507	*5,93,575*	27·59
1923-24	31,238	*7,68,858*	24·61
Average .	*22,969*	*5,70,520*	*24·84*

[1] Wrongly quoted in the previous Quinquennial Review (*Rec. Geol. Surv. Ind.*, Vol. LII, p. 263) as 29,485 cwts., owing to failure to subtract the exports.

TABLE 106.—*Imports of Borax by sea during the years 1919-20 to 1923-24.*

YEAR.	Quantity.	*Value.*	Value per cwt.
	Cwts.	Rs.	Rs.
1919-20	3,453	*92,690*	26·84
1920-21	12,157	*3,76,360*	30·96
1921-20	4,525	*1,65,621*	36·60
1922-23	11,849	*3,44,758*	29·09
1923-24	11,844	*2,84,086*	23·98
Average .	*8,766*	*2,52,703*	*29·49*

Of the amounts brought across the frontier, and shown in Table 105 to have an annual average of 22,969 cwts., only 117 cwts. came from Afghanistan and the rest from Tibet.

The borax obtained in the Puga valley of Ladakh, Kashmir, is deposited from hot springs associated with sulphur deposits, which probably represent the final phase of declining volcanic action. The material collected in Tibet is obtained from salt lakes, which have possibly obtained their borax in a similar way from hypogene sources. In other parts of the world, as in California, Argentina, Bolivia, and Chile, deposits of calcium borate, colemanite, are worked for their boracic acid, besides the borax of salt lakes and marsh deposits. In Italy borax is obtained from volcanic fumaroles.

Building Materials.

[E. H. PASCOE.]

As remarked by Sir Thomas Holland, "if the extent of the use of building materials could be expressed by any recognised standard, it would form one of the best guides to the industrial development of a country. The attempt made to obtain returns of building stones, road metal, and clays used in India was aban-

doned when it was shown, in 1899, that the returns could not possibly rank in value much above mere guesses."

In the absence of statistics, it is difficult to express shortly the trade in a material so widespread as common building stone. There are, however, a few features which are specially developed in, if not peculiar to, India. In the southern part of the Peninsula, various igneous rocks—the charnockite series near Madras, and the gneissose granites of North Arcot and Mysore—are largely used; in the centre, slates and limestones from the Cuddapah series, and basalt from the Deccan trap-flows are quarried. In Central India, the Central and United Provinces, the great Vindhyan system provides incomparable sandstones and limestones, while in Bengal and the Central Provinces the Gondwana sandstones are used on and near the coalfields. In the Narbada valley the so-called coralline limestone of the Bagh series forms an excellent building stone with a certain claim to inclusion in the ornamental class. Among the younger rocks the nummulitic limestones in the north-west and in Assam are largely quarried, while the foraminiferal Porbandar stone in Kathiawar is extensively used in Bombay and Karachi.[1]

The abundant development of concretionary carbonate of lime in the great alluvial plains, and the extensive development of laterite on the Peninsula and in Burma are dependent, in their more pronounced forms, on conditions peculiar to tropical climates, and these two substances, the so-called *kankar* and laterite, are about the most valuable assets in building material possessed by the country.

Imports.

The three great physical divisions of India, being the result of three distinct geological histories, show general contrasts in the materials available for simple as well as ornamental building purposes. In the great alluvial plains buildings of importance are usually made of brick, but the surrounding tracts furnish a supply of stone, which is steadily increasing with improved facilities for transport. The monotonous line of brick and stucco buildings in Calcutta is being relieved by the introduction of Vindhyan sandstones from Mirzapur and the calcareous freestones and buff traps brought from the western coast. But the use of Italian marbles, mainly for floorings and,

[1] A 'Memoir on the Economic Geology of Navanagar State' by G. E. Howard Adye (1914), deals with the economic uses of the miliolite limestones, Deccan Trap rocks, both acid and basic, and the laterite of this State.

in a smaller way, the introduction of polished granite columns and blocks from Aberdeen and Peterhead, have continued, mainly because these materials, which are no better than, and possibly on the whole inferior to, those of Indian origin, are placed on the market at cheap rates and in a manner suitable to the immediate requirements of the builder and architect. The distance of much of the Indian marble, especially the higher grade material, from the sea-board precludes cheap transport and prevents the Indian stone from competing in foreign markets with material from elsewhere. With regard to immediately local demand, however, this comparative inaccessibility protects indigenous supplies, which can undersell foreign marble the transportation of which includes a considerable land journey.

During the years 1919-20 to 1922-23 the value of building and engineering materials imported from foreign countries into India has had an average annual value of Rs. 1,82,70,779, exclusive of stone and marble, which have averaged Rs. 8,17,817 annually during the same period. The substances included in the trade statistics under the heading of building materials and entered into the above total comprise asphalt, bricks and tiles, cement, chalk and lime, clay and earthenware piping. The values of some of these are given in the section on clays. The quantity of cement imported annually, during the years 1919-20 to 1922-23 has averaged 120,342 tons valued at Rs. 1.19,10,127; and the annual imports of chalk and lime during the same period have averaged 1,676 tons valued at Rs. 75,904.

Ornamental building stone.

As Sir Thomas Holland has remarked,[1] "it is naturally surprising to find that a country. which owes its reputation for architectural monuments as much to the fact that it possesses an unlimited supply of ornamental building stone as to the genius of its people, is dependent on foreign supplies to the extent indicated by these import returns. It can hardly be an accident that each dynasty which has existed in India since the wonderful Buddhist topes of Sanchi and Bharhut were erected, has been marked by the erection of great monuments in stone, and there can be little doubt that the abundance of suitable material has been an important contributory cause in the growth of India's reputation for architecture."

[1] *Rec. Geol. Surv. Ind.* XXXII, p. 103.

Besides the architectural remains left by the Buddhists, there are famous works in stone by the Hindus of the eighth to tenth centuries, including the great Dravidian temples of Southern India, mostly built of granites and other crystalline rocks, and the richly ornamented buildings of Orissa and of Chanda built of Gondwana sandstones. The Pathans and Moghals utilised both the Vindhyan sandstones of Central India and the beds of marble in Rajputana for building their magnificent mosques, palaces and tombs in the cities of Northern India. It is only necessary to mention here Akbar's city of Fatehpur Sikri, where the red and mottled sandstone of the Bhander series was used, and the famous Taj, built mainly of white Makrana marble, with elaborate inlaid work of yellow marble and shelly limestone from Jaisalmer, onyx marble from the Salt Range, black calcareous shales from the Vindhyans of Chitor, malachite from Jaipur, carnelians and blood-stones from the Deccan trap, and red jasper from the Gwalior (Bijawar) series.

The delicate and intricate carvings, for which some varieties of the Indian sandstone are so well suited, are admirably shown in an 'Illustrated Catalogue of Ornamental Carved Stone in Gwalior,' published by the Department of Commerce and Industry, Gwalior, in 1912.

Although, in most cases, reliable statistics concerning the production of building stones in India are not obtainable, yet we give here such figures as are available, excluding those relating to marble and slate, which are treated in separate sections.

Granite and gneiss.

Gneissose granites and gneisses are used as building stones and for road-metal in many parts of Peninsular India, particularly in the Madras Presidency, for which returns have been available since 1910. Figures of production and value for Bihar and Orissa, Burma, and Madras are given in Table 107.

From 1907 to 1908 there was a sudden increase in the Burmese production of granite and gneiss, from 27,781 tons to 340,939 tons. This was largely due to the development of quarries in gneissose granite in the Thaton district for the supply of stone to the Burma Railways Company and the Town Lands Reclamation Works in Rangoon. Owing probably to the same causes the production of the Thaton quarries is reported to have reached the enormous figure of 7,642,268 tons in 1909, valued at £344,704.[1] Since then the

[1] The Government of Burma were unable to confirm this figure owing to the destruction of the district records.

production from this district has been relatively small, but in 1909 quarrying began at Kalagauk Island in the Amherst district in connection with the Rangoon River Training scheme. The output in 1909 was 57,500 tons which, with the introduction of a regular service of hopper barges, reached a total of 295,125 tons in 1912. With the completion of the scheme the works were closed down in 1914. During the previous quinquennial period there was a steady rise up to 1917 and a somewhat sharp fall of 72,000 tons in 1918 from Burma; during the five years 1919-23 there was a still further fall, the annual average amounts working out to less than 116,000 tons. The figures for Madras are as capricious in their fluctuation as they were in the preceding period, but are very much smaller; the average annual output has in fact been scarcely more than one-sixth of that during 1914-18. Too much significance must not be placed on these figures, which are probably largely affected by the periodical demand for road-metal for the town of Madras.

Sandstone.

The available figures for the production of sandstone in India are shown in Table 108. Those shown for the United Provinces refer to the output of Upper Vindhyan sandstone from the quarries at Chunar in the Mirzapur district. The figures for Bihar and Orissa refer chiefly to the output of Vindhyan and Gondwana sandstones, from the districts of Shahabad and Manbhum respectively. A quartzite of good quality from Susunia Hill, Bankura, has been largely employed in Calcutta for paving and curb stones. In Burma, sandstone is quarried in many districts, amongst which may be mentioned the Northern Shan States, Meiktila, Thaton, Minbu, Kyaukse, Pakokku, Amherst, Shwebo, and Akyab.

Limestone.

The subject of building materials naturally includes limestone used as a building stone, and the two derived products—lime and cement. In the present review cement is dealt with under a separate heading for the first time. Lime and cement are obtained, obviously, from the most conveniently situated deposits of limestones, such as those of the Upper Vindhyan series worked near Sutna in the Rewah State by the Sutna Stone and Lime Company, Ltd.; those of the Lower Vindhyan series worked at Katni in the Jubbulpore district by Messrs. Cook & Sons and others; those worked in the Cuddapah series at Bisra and Rourkela in Gangpur State by the Bisra Stone Lime Company; or the various bands of crystalline limestones in Madras, Central India, and Rajputana, and

TABLE 107.—*Production of Granite and Gneiss during the years 1919 to 1923.*

Province.	1919.		1920.		1921.		1922.		1923.			
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
Assam	..	..	..	..	8,364	*20,220*	3,274	*19,215*	2,648	*6,435*	†4,762	*†15,290*
Baroda	1,400	*17,220*	(*b*)	*1,000*	182	*4,995*	..	..	..	..	*791	*†7,738*
Bihar and Orissa.	..	..	..	..	..		1,478	*3,390*	1,284	*210*	*1,381	**1,800*
Burma	177,517	*3,43,100*	202,189	*2,94,080*	72,932	*1,16,580*	44,982	*71,625*	82,296	*2,04,885*	115,983	*2,06,054*
Hyderabad .	52	(*a*)	..	..	..	..	..	..	..	..	..	..
Madras .	53,930	*13,600*	12,060	*3,800*	26,218	*14,085*	16,785	*5,700*	5,992	*885*	22,997	*7,614*
TOTAL .	**232,899**	*3,73,920*	**214,249**	*2,98,880*	**107,696**	*1,55,880*	**66,519**	*99,930*	**92,220**	*2,12,415*	**145,914**	*2,38,496*
Total value in sterling		*£32,515* (£1=Rs. 1·5)		*£29,888* (£1= Rs. 10)		*£10,392* (£1= Rs. 15)		*£6,662* (£1= Rs. 15)		*£14,161* (£1= Rs. 15)		*£18,724*

(*a*) Not available.
(*b*) 500 cu.ft. weight in tons is not available.
† Average of 3 years.
* Average of 2 years.

TABLE 108.—*Production of Sandstone during the years 1919 to 1923.*

PROVINCE.	1919.		1920.		1921.		1922.		1923.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
Assam	..	..	..	..	..	..	..	..	1,967	*3,465*	..	..
Bihar and Orissa.	13,933	*11,150*	8,019	*18,380*	14,718	*19,875*	10,785	*19,440*	16,357	*25,455*	12,762	*18,860*
Burma	89,697	*1,33,540*	122,265	*1,45,200*	318,456	*2,05,740*	68,692	*70,125*	77,046	*76,110*	135,281	*1,26,743*
Central India	..	..	..		21,411	*1,07,505*	..	..	..	..	..	..
Gwalior	..	..	..		..	..	12,114	*48,075*	11,637	*69,240*	(*a*)11,875	(*a*)*58,657*
Mysore	..	..	..		..	..	..	..	5	*15*	..	..
Punjab	1,840	*3,900*	..	..	..	..	..	..	..	..	..	..
Rajputana	62,025	*1,77,300*	24,752	*2,59,000*	35,111	*2,47,020*	55,607	*2,27,685*	178,016	*11,04,270*	71,102	*4,03,055*
United Provinces.	6,000	*29,500*	7,000	*49,000*	4,909	*4,905*	..	..	..	..	(*b*)7,303	(*b*)*27,802*
TOTAL	**173,495**	*3,55,390*	**162,036**	*4,71,580*	**398,605**	*5,88,045*	**147,198**	*3,65,325*	**285,028**	*12,78,555*	**238,273**	*6,35,117*
Total value in sterling		*£30,904* (£1=Rs. 11·5)		*£47,158* (£1=Rs. 10)		*£39,203* (£1=Rs. 15)		*£24,355* (£1=Rs. 15)		*£85,237* (£1=Rs. 15)		*£45,371*

(*a*) Average of 2 years.
(*b*) Average of 3 years.

the nummulitic limestones of Assam. The last-mentioned stone is brought down by boat during the Rains from the southern scarp of the Khasi and Jaintia Hills to Sylhet where it is burnt in primitive kilns ; Calcutta at one time derived its main supply of building lime from this source. Vast quantities of limestone suitable for building-stone or for lime-burning, are available over large areas of Baluchistan. Such figures as are available for the production of limestone during the period under review are given in table 109.

The production of the Sutna Stone and Lime Company in Rewah may be gauged from the quantities despatched from the works during the five years 1919 to 1923, the quantity of limestone has averaged annually 56,978 tons valued at Rs. 55,879. During the period under review unslaked lime manufactured by this company has averaged 18,344 tons valued at Rs. 2,72,084; slaked lime has averaged 2,218 tons valued at Rs. 28,806, and stone setts have averaged 91,550 pieces valued at Rs. 10,585. As is shown by these figures, much of the limestone is not converted to lime ; it is instead railed a distance of 530 miles to the Barakar Iron Works, where it is used as a flux in the blast furnaces.

Besides the Maihar Stone and Lime Company, Limited, four other Companies, *viz.*, Madho Stone Lime Company, New Maihar Stone Lime Company, Imperial Lime Manufacturing Company and Jagahir Kamala Company are at present working for limestone in the Maihar State. The annual output from that state averaged 27,574 tons valued at Rs. 10,805 during the period 1919 to 1923.

The production from Bihar and Orissa is derived chiefly from Gangpur State with, in some years, large amounts of *kankar* and limestone from the Shahabad district. The Gangpur output includes the production of the Bisra Stone Lime Company which has averaged 92,703 tons valued at Rs. 1,48,766 (Re 1-10-0 per ton) or about double that of the previous quinquennium. The following amounts of dolomite from Panposh, used as a flux in their works at Sakchi, were produced by the Tata Iron and Steel Company, the annual average being 187,300 tons valued at Rs. 4,13,651 (Rs. 2-3-0 a ton) :-

	Tons.
1919	193,716
1920	156,528
1921	182,862
1922	209,901
1923	193,493
TOTAL	936,500

Towards the end of the quinquennium 1909-13 the opening of the Dehri-Rohtas Light Railway led to the formation of three companies—The Kalianpur Lime Works, Limited, The Kuchwar Lime and Stone Company, Limited, and The Sone Stone and Lime Works—to work the Rohtas (Vindhyan) limestone at and near Banjari in the Shahabad district. The output of limestone in the Shahabad district averaged 133,065 tons valued at Rs. 2,26,558 and that of lime 48,226 tons valued at Rs. 3,07,115.

The production shown for the Central Provinces is derived mostly from Katni, where the limestone quarries come under the control of the Indian Mines Act. The quantity raised under this Act has varied from 123,119 tons in 1922 to 264,939 tons in 1921, the average for the quinquennium being 171,416 tons worth Rs. 2,95,979. The average daily labour employed is shown below separately for each year, the average for the period being 4,485 persons. The number of deaths has been 5 giving an average death-rate of 0·22 per 1,000.

Production of Limestone from Katni Act-Mines and labour statistics.

——	Quantity.	*Value.*	Persons employed daily.
	Tons.	*Rs*	
1919	133,016	*1,79,996*	2,251
1920	120,082	*1,65,547*	3,701
1921	264,939	*4,32,548*	6,265
1922	123,119	*2,81,029*	3,840
1923	215,924	*4,20,775*	6,427
Average .	*171,416*	2,95,979	4,485

A very small proportion of the limestone, shown as quarried in Assam, comes from the Lakhimpur district and Manipur, practically the whole of the output being from the Khasi and Jaintia Hills, where the nummulitic limestone is being worked by the Sylhet Lime Company, Limited. The output from this province has varied

from 63,674 tons in 1919 to 121,983 tons in 1923, the average quantity being 89,581 tons worth Rs. 2,12,897.

As regards the other areas reported as producing limestone, that in Baluchistan comes from the Las Bela State; the limestone of Burma comes from many localities, the most important of which are Mandalay district, Kyaukse district, the Southern Shan States, the Northern Shan States, and Meiktila district; a large proportion of the Madras production comes from the Cuddapah district. The small production reported from the Punjab comes from the Jhelum, Hoshiarpur and Ambala districts, whilst the output reported from Rajputana comes chiefly from Alwar and Sirohi. The small production reported from the United Provinces comes from the Naini Tal, Almora, Garhwal, and Dehra Dun districts.

Kankar.

One of the most widespread and interesting sources of lime is the material generally known by the name of *kankar*, some of the more solid varieties of which have found a limited use as building-stone. The commonest mode of occurrence is in the great alluvial deposits, particularly in the older alluvium, in which the calcareous substances have segregated from the rest of the materials and have grown into irregular lumps like flints in chalk, including in the concretions a certain amount of the argillaceous substances, which when the *kankar* is burnt, is present in a proportion not far removed from that necessary to produce a hydraulic lime. The material of these concretions constitutes, in fact, a "natural cement."

Another industry for which it is hoped a high grade limestone will be in increasing demand is the manufacture of calcium carbide and calcium cyanamide. The latter is becoming increasingly important as a nitrogenous manure and a greater supply would in all probability create its own demand.

Laterite.

The curious superficial rock known as laterite is widely distributed over the whole of the Peninsula of India and in Burma. In certain cases it has a special value as an ore of aluminium (see page 252), iron or manganese, according to composition (see page 192), but it is also very widely used as road-metal and as a building stone for culverts and buildings; for the latter purpose it possesses one advantage over other stones in the ease with which it can be cut into blocks and its power of subsequently hardening when exposed to the air. In most cases, no statistics are collected. In Table 110 are given the statistics

TABLE 109.—*Production of Limestone and Kankar during the years 1919 to 1923.*

Province.	1919.		1920.		1921.		1922.		1923.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
Assam . .	63,674	*1,42,070*	69,990	*1,43,540*	98,391	*2,25,510*	98,869	*2,77,920*	121,983	*2,75,445*	89,581	*2,12,897*
Baluchistan .	..	..	..	..	..	..	2	(*a*)	2	(*a*)	..	..
Bihar and Orissa.	380,288	*8,23,060*	379,638	*7,44,270*	471,977	*7,03,065*	436,709	*7,98,540*	432,048	*9,26,160*	420,132	*7,99,079*
Burma . .	214,274	*3,25,550*	254,540	*3,15,390*	236,451	*3,01,035*	164,693	*2,42,865*	234,770	*4,01,895*	220,945	*3,17,347*
Central India .	66,960	*66,833*	58,590	*37,884*	95,617	*1,23,160*	83,158	*92,955*	1,18,987	*68,059*	84,662	*77,778*
Central Provinces	137,488	*1,89,300*	138,240	*1,94,640*	335,349	*5,44,995*	161,367	*3,88,320*	259,986	*5,31,435*	206,486	*3,69,738*
Gwalior . .	..	..	..	..	..	..	2,684	*11,730*	1,971	*6,645*	931	*3,675*
Madras . . .	17,490	*16,340*	12,759	*11,430*	17,460	*64,065*	20,065	*72,330*	20,730	*69,030*	17,701	*46,639*
Mysore . .	..	..	989	*9,890*	306	*1,950*	14,854	*14,955*	9,915	*33,435*	5,213	*12,046*
North-West Frontier Province.	11,217	*7,570*	5,160	*4,180*	1,671	*4,350*	..	..	..	..	4,209	*3,220*
Punjab . .	31,046	*60,810*	27,232	*62,960*	30,597	*31,935*	39,513	*34,575*	33,248	*26,745*	32,827	*43,405*
Rajputana .	812	*7,190*	3,028	*5,164*	1,948	*2,460*	33,639	*47,219*	142,451	*2,33,748*	36,376	*59,156*
United Provinces.	2,432	*9,270*	2,710	*15,280*	3,63,607	*2,40,255*	126,161	*1,69,230*	104,999	*1,43,340*	119,982	*1,15,475*
TOTAL .	**925,681**	*16,47,993*	**952,876**	*15,44,628*	**1,656,374**	*22,42,780*	**1,176,714**	*21,50,939*	**1,481,090**	*27,15,937*	**1,238,545**	*20,60,455*
Value in Sterling		*£143,304* (£1 = Rs. 11·5)		*£154,463* (£1 = Rs. 10)		*£149,519* (£1 = Rs. 15)		*£143,396* (£1 = Rs. 15)		*£181,062* (£1 = Rs. 15)		*£154,349*

(*a*) Value not available.

TABLE 110.—*Production of Laterite during the years 1919 to 1923.*

PROVINCE.	1919.		1920.		1921.		1922.		1923.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
Assam .	..	..	..	..	(a)2,600	*4,395*	3,645	*7,920*	3,836	*9,090*	..	..
Bihar and Orissa.	1,523	*560*	1,212	*240*	560	*345*	602	*285*	5,143	*1,260*	1,808	*538*
Bombay .	..	..	..	..	..	..	..	..	540	*750*	..	..
Burma . .	247,444	*3,27,850*	279,871	*3,47,910*	287,527	*5,25,075*	231,372	*2,22,330*	158,376	*2,17,035*	240,918	*3,28,040*
Madras . .	103,314	*81,410*	93,988	*87,690*	58,751	*45,210*	150,028	*67,860*	80,414	*56,955*	97,299	*67,825*
Mysore . .	..	..	..	..	..	..	..	..	3,548	*7,680*	..	..
TOTAL .	**352,281**	*4,09,820*	**375,071**	*4,35,840*	**349,438**	*5,75,025*	**385,647**	*2,98,395*	**251,857**	*2,92,770*	**340,025**	*3,96,403*
Total value in Sterling		*£35,637* (£1= Rs.11·5)		*£43,584* (£1= Rs.10)		*£38,335* (£1= Rs.15)		*£19,893* (£1= Rs.15)		*£1 ,518* (£1= Rs.15)		*£31,393*

(a) Excludes 1,600 tons, the value of which is not available.

as far as available. The figures for Assam relate to Sylhet and the Khasi and Jaintia Hills, while those for Bihar and Orissa refer to the Puri and Singhbhum districts and the Nilgiri State. The annual Burmese output averaged 240,918 tons valued at Rs. 3,28,040. The output comes from some twenty districts, but by far the most important are Amherst with an average annual output during the period of 44,464 tons, Hanthawaddy with 21,378 tons, Insein with 37,933 tons and Thaton with 82,572 tons. The laterite of Madras comes from Nellore, Trichinopoly, Malabar and Chingleput districts, the last two contributing annually on an average 40,403 tons and 54,366 tons respectively.

Gravel.

The mineral returns of Burma regularly give details of the production of gravel in various districts; the total figures are—

			Rs.
1919	57,815	tons valued at	30,937
1920	141,347	,, ,, ,,	69,876
1921	121,284	,, ,, ,,	51,532
1922	119,237	,, ,, ,,	45,703
1923	119,072	,, ,, ,,	54,666
Average	*111,751*	,, ,, ,,	*50,543*

The most important districts are Henzada, Mandalay, Lower Chindwin, Tavoy, Thaton, Minbu, Shwebo and the Northern Shan States. The material is used for the repair of roads.

A hard conglomerate, occurring below the Mergui series, is being quarried in Pataw Island opposite the town of Mergui, and used in the harbour construction work along the margin of the town.

Cement.

[H. C. Jones.]

During the last ten years the growth of the Portland Cement industry in India has been great. Since the last quinquennial review of the mineral production of India, several companies have been formed, factories built, and towards the end of the five years, some of the new companies began putting their products on the market. The older companies also largely increased their output during the five years. This increased output together with the

increased importation of foreign cement, which had been largely stopped during the War, and the trade depression, caused prices to fall considerably.

Portland cement is an artificial chemical compound having a fairly well-defined composition, and is usually produced by the action of intense heat on a finely ground mixture of limestone or marl with clay or shale. It can be produced from raw materials differing greatly in composition, texture, etc., but the mixture should contain about 75 per cent. of calcium carbonate and 25 per cent. of clay material. Occasionally an argillaceous or clayey limestone occurs in which the essential constituents of cement are present in almost the correct proportions, as in the case of *kankar* (*q. v.*). In such a case very little additional material will be required to bring the mixture to the correct composition. This however is unusual, and in India it is customary to use a mixture of limestone which provides the calcium, and shale or clay which provides the alumina, silica, and iron. The Madras Portland Cement Company, Limited, apparently obtain their calcium from shells, which are quarried in the Chingleput district. Most of the other companies use limestone.

The calcium in most limestones is partly replaced by magnesium but for Portland cement, the amount should not be more than 3 to 4 per cent. of magnesium carbonate.

I am indebted to Messrs. Martin and Company, the Managing Agents of the Sone Valley Portland Cement Company, for the following account of the works and factory at Japla in the Palamau district :—

"The raw materials utilised are limestone and shale, the former being quarried on the lower slopes of the eastern escarpment of the Kymore hills at Rhotas, where the steep limestone slope rises nearly 350 feet above the level of the plain and can be most easily worked. A ropeway, five miles long conveys the selected limestone to the Cement works, crossing the river Sone *en route*, and dropping the stone directly into the storage bin of the Raw Material Mill in the factory standing close to the eastern bank of the river. The shale is obtained near the East Indian Railway line at Daltonganj and is conveyed thence by railway to the factory, a distance of about 50 miles. The limestone having been automatically discharged from the ropeway buckets into the limestone bin passes automatically thence through two heavy crushers and thence through heavy rolls. The shale, as discharged from the railway waggons, is passed through a crusher

and is elevated into a hopper whence it is fed by a revolving measuring table into the similarly measured stream of limestone passing to a great Ball Mill within which balls crush and mix the two materials, until the product becomes small enough to escape through the grids with which this mill is fitted. Water is admitted to the Ball Mill during this process and the mixture is thereby converted into a thin creamy mud technically known as "slurry." Passing from the Ball Mill, the "slurry" enters two large revolving Tube Mills half filled with round flints. These machines grind the materials fine enough to leave a residue not exceeding five per cent. on a sieve having 32,400 holes per square inch. Thence the stream of slurry passes to the "mixers" or storage basins which are equipped with rotating stirrers. The slurry is not allowed to leave the mixers until it has been sampled and found to be of correct composition. The slurry is pumped into a machine fixed above the kiln, for the purpose of regulating its feed. The kiln is a long steel tube lined with firebricks and rotating slowly on heavy steel rollers. The slurry gradually works its way towards the lower end, the water in it being driven off by the hot gases passing from the burning zone to the chimney shaft. Finely ground coal is blown in by a fan at the lower end of the kiln and there forms a great flame which fills the entire burning zone and creates a temperature ranging between 2,400 and 3,000° Fahrenheit. This raises the dried lumps of slurry to a white heat and causes a chemical combination of the lime with the silica and alumina, resulting in a clinker, in size ranging from that of a pea to that of a tennis ball with occasional larger pieces as big as a man's head. The clinker falls from the lower end of the kiln into another revolving steel cylinder, equipped with longitudinal bars which keep lifting the hot clinker up and allowing it to drop through the in-rushing air. By this means the clinker is cooled. The cooled clinker emerges from the lower end of the cooler and drops into a series of elevators which carries it into the clinker store. Through numerous holes in the floor of this store the clinker falls into a conveyor which carries it to the Mill, where, in a Ball Mill and two Tube Mills similar to those used in the Raw Material Mill, it is reduced to a fineness which leaves a residue of only about 5 per cent. on a sieve having 32,400 holes per square inch. Other conveyors and elevators take the finished cement to the storage bins. The capacity of the present plant is about 1,200 tons per week or about 60,000 tons per year."

Clays.

[H. C. JONES.]

Importance of clay as a mineral product.

The important part played by clay in the industrial development of a country is not generally recognised, but can easily be illustrated by reference to the mineral statistics of such an industrially advanced country as the United Kingdom. From Table 2 on page 7 it will be seen that in 1922, clay ranked third in value amongst the mineral products of that country; the output in that year was 9,078,091 statute tons valued at £2,610,085. The figures for the United States relate not to the raw material, but to the products manufactured therefrom, and the magnitude of the total value—£72,572,100—can be grasped when it is pointed out that this is more than three times the value of the total Indian mineral output for the same year of all minerals for which reliable statistics are available.

Production in India.

No statistics approaching any degree of completeness are obtainable to show the extent of the undoubtedly great industrial value of the clays in India, but the figures for the production during the last quinquennium show a large increase over those of the previous period. This is no doubt partly due to the more complete returns that have been obtained. They include the common clays, derived largely from the silt of the large rivers and used all over the country for the manufacture of bricks, tiles and the cheaper forms of pottery; finer varieties used for glazed pottery, which in places has obtained a reputation for artistic merit; fire-clays raised in considerable quantities on some of the Gondwana coal-fields; and Fuller's Earth, which is mined in the Central Provinces, Mysore and Rajputana.

The reason for the smallness of the figures for Madras, United Provinces and possibly some of the other areas is that information on ordinary clay has been omitted from annual returns since 1911. The consumption of building bricks in India, of which no returns are available, probably reaches a high figure. The output for the five years 1919-23 is summarised in Table 111, from which it will be seen that the average annual output has been 154,214 tons valued at Rs. 3,92,873 giving an average value of about Rs. 2 as. 9 per

TABLE 111.—*Production of Clay in India during the years 1919 to 1923.*

	1919.		1920.		1921.		1922.		1923.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.
Bengal	25,309	*23,390*	19,911	*19,371*	9,117	*19,413*	13,307	*14,877*	38,396	*62,952*	21,208	*28,001*
Bihar and Orissa	57,668	*3,45,780*	35,005	*2,60,639*	32,280	*3,35,177*	6,548	*1,37,429*	7,953	*1,28,904*	27,891	*2,41,586*
Burma	22,692	*21,673*	22,620	*17,823*	39,321	*27,765*	21,048	*24,667*	34,871	*40,767*	28,110	*26,539*
Central India	539	*996*	2,651	*(a)519*	669	*1,630*	18	*45*	386	*670*	853	*772*
Central Provinces	60,637	*44,383*	59,317	*36,900*	52,284	*31,869*	50,180	*28,926*	37,279	*21,360*	51,939	*32,688*
Delhi	714	*1,200*	8,025	*8,014*	12,801	*28,449*	7,958	*14,892*	3,676	*3,908*	6,635	*11,293*
Gwalior	..	..	545	*958*	577	*1,238*	410	*2,116*	536	*7,326*	(c)413	*2,327*
Madras	..	..	..	..	..	..	12	*70*	110	*200*	(c)24	*54*
Mysore	2,139	*21,390*	2,562	*25,625*	52,328	*1,15,156*	2,943	*29,430*	23,985	*52,201*	16,791	*48,760*
Rajputana	..	..	..	..	464	*(b)1,160*	331	*1,050*	920	*2,045*	(c)343	*851*
United Provinces	35	*10*	..	..	..	..	..	..	..	..	(c)7	*2*
TOTAL	169,733	*4,58,822*	150,636	*3,69,849*	199,841	*5,61,857*	102,755	*2,53,502*	148,112	*3,20,333*	154,214	*3,92,873*
Total value in Sterling.	..	*£39,898* £1= Rs. 11·5	..	*£36,985* £1= Rs. 10	..	*£37,457* £1= Rs. 15		*£16,900* £1= Rs. 15		*£21,356* £1= Rs. 15	..	*£30,519* ..

(*a*) Excludes the value of 2,445 tons of clay produced in Rewa State.
(*b*) " " 90 tons " " Alwar State.
(*c*) Average of 5 years.

ton. The average annual output shows a big increase both in quantity and value over the average of the previous five years when it was 83,585 tons valued at £6,838 (Rs. 1,02,570).

Fuller's Earth is obtained at Katni in the Jubbulpore district of the Central Provinces, where it occurs in the Lower Vindhyan series. A form of Fuller's Earth known as *multani-matti* is also worked in the States of Bikanir and Jaisalmer in Rajputana; this and other varieties are eaten in various parts of India. A steady supply has been derived also from Marwar in Rajputana. The production from Jubbulpore and Marwar during the period under consideration was:—

TABLE 112.—*Production of Fuller's Earth during the years 1919 to 1923.*

—	1919.		1920.		1921.		1922.		1923.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.
Central Provinces— Jubbulpore . .	247	*1,211*	197	*967*	113	*554*	152	*748*	80	*393*
Mysore— Tumkur . .	..	..	..	..	139	*195*	..	..	..	..
Rajputana— Bikanir State .	..	..	..	..	1,675	**8,799*	1,387	*7,356*	110	*585*
Jaisalmer State .	..	..	..	..	..	..	11	*100*	6	*90*
Jodhpur State . .	1,129	*4,200*	2,300	*8,400*	580	*4,942*	12,000	*28,560*	27,500	*56,100*
TOTAL .	**1,376**	***5,411***	**2,497**	***9,367***	**2,507**	***14,490***	**13,550**	***36,764***	**27,696**	***57,168***
Total value in Sterling	..	*£471*	..	*£937*	..	*£966*	..	*£2,451*	..	*£3,811*
		£1= Rs. 11·5		£1= Rs 10		£1= Rs. 15		£1= Rs. 15		£1= Rs. 15

The Bengal output is derived from the Burdwan district. That of the Central Provinces is mainly from the Jubbulpore district with a small production from the Hoshangabad district. The main portion of the Jubbulpore output is derived from quarries in the Upper Gondwanas near Jubbulpore town and is used in the pottery works of Messrs. Burn & Company and of the Perfect Pottery Company. But a certain amount of clay was won by the Katni Cement and Industrial Company at Tikuria near Katni. The Madras production is derived chiefly from the districts of Ganjam, South Kanara, Ramnad, Tinnevelly and Trichinopoly.

Pottery clays are worked in various parts of India, amongst which may be mentioned Jubbulpore (from the Jabalpur division of the Gondwanas).

In addition to the common clays used by the native potter in making common earthenware articles by means of the potter's wheel, there are in India many clays of finer quality used in large pottery works, such as those of Jubbulpore and Raniganj, where, however, the chief productions are drain-pipes, roofing and flooring tiles, fire-bricks, etc. There can be little doubt that India possesses also all the materials necessary for the manufacture of porcelain of the highest quality, such materials being found in the Jubbulpore district and the Rajmahal Hills.

The china-clay and fire-clay deposits of the Rajmahal Hills were investigated by Dr. Murray Stuart,[1] who reports most favourably on their suitability for manufacturing porcelain and fire-bricks of the highest quality. The Calcutta Pottery Works has been using kaolin from Mangal Hat in the latter area and has succeeded in producing cups, saucers, jugs, and ornaments of common white porcelain.

Testing of Indian clays.

Some years ago a series of 95 samples of Indian clays was subjected to a critical examination at the Imperial Institute, and a report on them submitted by Professor W. R. Dunstan. The clays were carefully inspected, and a number of samples typical of the various groups were selected and submitted to complete chemical analysis. The remainder were subjected to working and firing trials with a view to the observation of their plasticity, refractoriness, and the nature of the product obtained on firing, which are the properties on which the commercial and manufacturing value of clays depends.

[1] *Rec., Geol. Surv., Ind.*, XXXVIII, pp. 133—148 (1909).

The series of clays was divided into two groups (1) kaolins and (2) terra-cotta clays, the latter group comprising by far the larger number of the samples.

The *kaolins* examined were usually of inferior quality, and not in a sufficiently good mechanical condition to be suitable for the manufacture of thin wares such as those produced by 'slip' casting, though it is probable that by careful levigation some of them could be rendered suitable for working by this process.

The *terra-cotta* clays are suitable for the manufacture of stoneware, ornamental vases and tiles, and bricks of good quality. The following analyses are given :—

TABLE 113.—*Analyses of Indian clays (percentages).*

—	1	2	3	4	5	6
Potash	0·61	0·21	*Nil*	0·24	0·24	0·07
Soda	0·41	0·25	*Nil*	0·72	0·51	0·20
Lime	1·85	0·13	0·26	*Nil*	0·46	0·30
Magnesia	1·32	0·54	1·63	0·48	3·09	*Nil*
Manganous oxide	0·12	..	*Nil*	..	..	..
Ferrous oxide	0·67	0·45	0·58	0·51	4·02	2·38
Ferric oxide	0·66	1·61	1·16		3·47	4·81
Alumina	32·75	24·82	21·06	13·04	20·28	21·22
Titanic oxide	0·51	..	0·35	..	0·61	trace.
Silica	46·31	64·06	69·95	80·15	56·21	61·43
Carbon dioxide	2·02	..	0·02	..	2·05	0·72
Water	12·40	7·70	4·69	4·75	8·86	9·42
	99·63	99·77	99·70	99·89	99·80	100·61

NOTES.—No. 1. Prepared white kaolin ; from N. Arcot, Madras.
No. 2. Soft pale grey kaolin ; from Hoshangabad, Central Provinces.
No. 3. Soft white kaolin with some pinkish material ; from Bangalore, Mysore.
No. 4. White impure kaolin, subjected to levigation before analysis ; from Shillong, Khasi and Jaintia Hills.
No. 5. Prepared grey clay from Bagirhat, Bengal ; a good example of a *terra-cotta* clay.
No. 6. Dark brown clay with red and yellow ochre in large specks ; from Hanthawaddy, Burma.

Of the clays represented by the above analyses, No. 1 was reported to be suitable for the manufacture of good quality earthenware or porcelain; No. 2 for the same purpose after careful preparation; No. 3 highly refractory and suited for the manufacture of fire-brick or earthenware; No. 4 suitable for fire-bricks or to reduce shrinkage when mixed with kaolin; Nos. 5 and 6 suited for the manufacture of *terra-cotta* ware.

TABLE 114.—*Value of Imports into India of Clay and Clay Products during the years 1919-20 to 1923-24.*

Year.	Earthenware and porcelain.	Earthenware piping.	Bricks and tiles.	Clay.	Total annual imports.
	Rs.	Rs.	Rs.	Rs.	Rs.
1919-20 . .	73,39,120	8,370	17,95,040	1,36,120	**92,78,650**
1920-21 . .	90,19,253	73,980	63,01,247	2,38,050	**1,56,32,530**
1921-22 . .	79,43,341	1,72,321	41,12,202	2,32,788	**1,24,60,652**
1922-23 . .	79,72,167	2,64,494	35,71,640	1,59,017	**1,19,67,318**
1923-24 . .	67,76,430	3,14,376	26,73,781	1,40,061	**99,04,648**
Average .	*78,10,062*	*1,66,708*	*36,90,782*	*1,81,207*	**1,18,48,759**

Imports.

The imports of materials coming under this section—namely, earthenware and porcelain, earthenware piping, bricks and tiles, and clay—are shown in Table 114, from which it will be seen that there was a large increase (over 68 per cent.) from 1919-20 to 1920-21, after which there was a steady decline during the rest of the period. The average annual value of these imports was Rs. 1,18,48,759 as compared with Rs. 70,78,020 during the preceding five years. As the average value of the exports and re-exports of clay, and clay products during the period has amounted only to Rs. 9,63,885, the total Indian consumption of such products exceeds the internal production by Rs. 1,08,84,874 indicating considerable scope for the development in the country of industries making use of clay.

Cobalt.

[E. H. PASCOE.]

Cobaltite, a sulph-arsenide of cobalt, and danaite, a cobaltiferous arsenopyrite, have been found as minute crystals disseminated amongst the slates of the Aravalli series at Khetri [1] and other places in Rajputana. These ores have been used for the manufacture of various sulphates. The minerals were formerly separated for the production of *sehta*, which is used by the Indian jewellers for producing a cobalt-blue enamel. The sulphide of cobalt, linnæite ($Co_3 S_4$) has been identified in the Geological Survey Laboratory amongst some ores of copper sent a few years ago from Sikkim by Colonel Newcomen. Some years ago specimens of a matte containing 11 per cent. to 14 per cent. of cobalt, the rest being iron and sulphur, were received in the Geological Survey Office, but no details as to the mode of occurrence have ever been received.[2] Small quantities of cobalt and nickel are frequently detected in the Indian manganese-ores; the best sample is the cobaltiferous wad of Olatura in the Kalahandi State, a specimen of which yielded 0·82 per cent. of cobalt oxide (CoO).

Corundum.

[E. H. PASCOE.]

The use of abrasives in manufacturing communities seems to be on the increase, and new forms are being put on the market yearly. Emery formerly served most requirements, until purer forms of corundum were discovered in quantity. The cheaper forms of garnet have long been used to adulterate emery, and members of the spinel family, such as hercynite, have been used inadvertently as such. During the last twenty years carborundum, manufactured by the cheap electrical power developed in America, has come into use, the production of the United States having now reached several thousand tons a year. Two artificial forms of corundum (alundum and aloxite) are being manufactured from bauxite and emery,

[1] *Rec., Geol. Surv., Ind.*, XIV, pp. 190—196 (1887); see also A. M. Heron, *Rec., Geol. Surv., Ind.*, XLIV, p. 10 (1914).
[2] E. J. Jones, *Rec., Geol. Surv., Ind.*, XXII, p. 172 (1889).

respectively, at Niagara, and crushed steel is being used to an increasing extent.

Natural corundum has thus many competitors in the market of abrasive materials, and as a large portion of the alumina in igneous magmas is necessarily used up during the processes of consolidation by the silica and bases present, it is theoretically unlikely that the free oxide can exist anywhere in an abundance comparable to the vast quantities of combined alumina in the earth's crust. In most cases the corundum is scattered as isolated crystals through the rock, and only the most economical devices for its separation can make mining remunerative.

In India, where the use of corundum by the old *saikalgar* (armourer) and lapidary has been known for many generations, the requirements of the country have been met by a few comparatively rich deposits, but it is doubtful if these are worth working for export in the face of the competition referred to above in Europe and America, or will even stand against the importation of cheap abrasives.

There is still, and for many generations has been, a certain trade in Indian corundum, but the returns for production are manifestly incomplete. No workings exist of the kind that could be ordinarily described as mining, but attempts have been made at times to increase the scale of operations at Palakod and Paparapatti in the Salem district, near Hunsur in Mysore, and in South Rewah.

The occurrence near Pipra in Rewah State was worked during the first two years of the period by Indian traders of Mirzapur.

Production.

A peak production of 1,860 cwts. was obtained in 1913 but the supply fell to an average of nearly 400 cwts. during 1914-18. In 1919 it again rose to 1,471 cwts. followed by 882 cwts. in the following year, but the mines have not been worked since 1920.

Corundum is very widely distributed throughout the Mysore State and is said to occur in every district except Shimoga. In 1914 the output came from Kolar, in 1915 from Kolar (76 cwts.) and Tumkur (843 cwts.), and in 1916 from the Mysore district. The average annual production during the quinquennium 1914-18 was 523 cwts. valued at Rs, 1,560 ; there has been no output during the 5 years under review.

Of the production of corundum recorded from the Madras Presidency, 211 cwts. from Coimbatore and 478 cwts. from Trichinopoly

made up the supply for 1914, but throughout the remainder of the period (1915-18) the whole of the output, averaging 31½ cwts. annually, came from South Kanara. During the quinquennium under consideration there was no output from Madras.

Much of the corundum, which is a regular item of trade in the bazars of cities like Delhi, Agra, and Jaipur, where the Indian lapidary still flourishes, is collected in a casual way by agriculturists and cowherds, who dispose of it through the village *bania* to the larger dealers of the great cities. Our information as to the mode of occurrence and distribution of the mineral was summarised in a special memoir published by the Geological Survey in 1898.

Khasi Hills.

Corundum (*mawshinrut*) is known to occur at three localities in the Nongstoin State in the North-West Khasi Hills, but much of the material obtained in this province in recent years is now known to be sillimanite (q.v.). The localities have, so far, proved to be too difficult of access for the exploitation of either mineral on a large scale, but corundum is worked in small quantities and used all over the Khasi Hills for hones.[1] The reported output of corundum from the Khasi Hills was 12,660 cwts. in 1919, 3,320 cwts. in 1920 and 1,277·6 cwts. in 1921, but it is not known what proportion of this was sillimanite. No production of corundum is reported for the last two years, 1922 and 1923.

Gem varieties of corundum are treated under 'Gem-stones.'

Canadian corundum.

The chief producers of corundum and emery are Canada, Turkey, and Greece, Canada supplying corundum, and Turkey and Greece emery. The Canadian corundum is found in Ontario in association with nepheline-syenite like that near Kangayam in the Coimbatore district.[2] By the adoption of mechanical means for concentration it has become possible to separate corundum from the felspar-rock in which it is embedded, and to put a product on the market, not only for local use, but for export to the United States and Europe.

The Canadian industry commenced in 1900, and the annual production for the five years 1914-18 averaged 240 tons valued at £6,876, an output which was less than one-sixth of what it had been before the war. No corundum has been produced in Canada since the war.

[1] F. E. Jackson, *Rec., Geol. Surv. Ind.*, XXXVI, p. 323 (1908).

[2] T. H. Holland, 'The Sivamalai series of Elæolite- and Corundum-Syenites. *Mem., Geol. Surv., Ind.*, XXX, pt. 3 (1901).

Fluor-spar.

[E. H. PASCOE.]

Fluor-spar has been obtained at Barla in the Kishengarh State, Rajputana, but the work of excavation was abandoned under a mistaken impression that the mineral was an inferior form of amethyst. Apparently the mineral forms with calcite and quartz a vein about a foot in thickness traversing gneiss. This occurrence was investigated by the Tata Iron and Steel Company, who report that very little fluor-spar was present, and that the cost of working it would exceed that at which they are able to purchase it from Europe; their imports of fluor-spar for use as a flux in the manufacture of steel amounted to 500 tons during each of the years 1919 to 1923.

Fluor-spar has also been found as small crystals in a dyke of quartz-porphyry near the copper-ore lodes of Sleemanabad, Jubbulpore district [1]; another occurrence in the Central Provinces is known at Chicholi in the Drug district, where it accompanies galena and copper carbonate in a quartz vein traversing gneiss.[2] Other localities recorded for the mineral are near Rewah [3] in one of the Vindhyan limestones; in the granitic veins of the Sutlej valley, North-West Himalayas[4]; and in limestone in the Amherst district, Burma. No indication of large deposits has been noticed at any of the localities.

Gem-stones of lesser importance.

[E. H. PASCOE.]

The most valuable of the precious stones raised in India is undoubtedly the ruby, but this and the other stones obtained in the country do not approach in value the unset stones and pearls imported, which, during the period under review, had an average annual value of Rs. 1,17,44,719 (compared with Rs. 46,83,510 during the previous quinquennium).

[1] L. L. Fermor, *Rec., Geol. Surv., Ind.*, XXXIII, p. 63 (1906).
[2] W. T. Blanford, *Rec., Geol Surv., Ind.*, III, p. 44 (1870).
[3] F. R. Mallet, *Mem., Geol. Surv., Ind.*, VII, p 122 (1871).
[4] F. R. Mallet, *Mem., Geol. Surv., Ind.*, V, p. 166 (1866).

Of the precious and semi-precious stones in India, the most important, amber, diamond, jadeite, ruby, sapphire, and spinel, have been already referred to. Of the others, the only ones that are of immediate concern are agate, rock-crystal, beryl, garnet, tourmaline, and turquoise. All of these except the last have been or are still being worked to some extent in India; the turquoise may be dismissed with the mere mention of the fact that India, besides being a large importer for local use, is one of the channels by which the material raised in Persia and adjoining areas reaches the European and Eastern market. The other minerals—with some other Indian stones at present used very little or not at all—deserve more particular mention.

Agate.

Until the last six years there has been a considerable trade in agate and the related forms of silica, carnelian, onyx, etc., known under the general name of *hakik*, and obtained from the amygdaloidal flows of the Deccan Trap. The best known and most important of the places at which agate and carnelians have been cut and prepared for the market is Cambay, the chief city of the State of that name under the Kaira Political Agency, Bombay Presidency. The agates come from various States and districts on or near the edge of the Trap, the chief sources of supply being the Kistna, Godavari, Bhima, Narbada and other rivers draining trap-covered areas. A large proportion of the pebbles comes from the State of Rajpipla. An account of the Rajpipla agate industry has been given by Mr. P. N. Bose.[1] The agates occur in a conglomerate of probably Pliocene age, and have been worked chiefly at Ratanpur and Damlai. The stones are chipped at the mines, and those approved of taken to Limodra, where they are baked. The baked stones are sent to Cambay for cutting and polishing. The Rajpipla *hakik* mines are leased for periods of five years at a fixed annual rental or royalty. This was Rs. 3,000 a year for the period 1902-06. No precise data as to the value of the stones sent to Cambay are available. The Rajpipla mines have not been worked since 1917. A certain amount of agate-cutting is also carried on at Jubbulpore in the Central Provinces, at Banda in the United Provinces, and at a few other places within range of the Deccan Trap.

Much of the agate retailed in Europe is sent from Cambay, and large quantities are also exported to China from that city.

[1] *Rec., Geol. Surv., Ind.*, XXXVII, pp. 176—182 (1908).

Various forms of quartz—rock-crystal, amethyst, etc.—are used by jewellers in various parts of India.

Rock-crystal.

In the Tanjore district, Madras Presidency, fragments of rock-crystal are collected and cut for cheap jewellery, being known as 'Vallum diamonds,' whilst the bipyramidal quartz-crystals, found in the gypsum of the salt-marl near Kalabagh and Mari, on the Indus, are to a certain extent used for making necklaces; these crystals are sometimes known as 'Mari diamonds.' Rock-crystal is similarly used for cheap jewellery in Kashmir; an output of 24 lbs. was reported from the Skardu Tehsil in 1921. Fine pieces of rock-crystal are sometimes cut into cups, sword handles, and sacred objects, such as *lingams*, in Northern India.

Amethyst and rose-quartz.

Small amethysts, usually of uneven colour, are obtained at many places from Deccan Trap geodes, *e.g.*, in the bed of the Narbada near Jubbulpore, and used for jewellery and beads. Amethyst is common in the Sutlej valley in Bashahr, Punjab.[1] Rose-quartz is found in the Chhindwara district, at Warangal in Hyderabad and in other places[2]; it is used in cheap jewellery.

Apatite.

Green apatite derived from pegmatites in Ajmer in Rajputana is sometimes cut into gem-stones, and a considerable quantity of apatite of a rich sea-green colour has been found at Devada, Vizagapatam district, Madras, derived probably from a pegmatitic variety of kodurite.[3] Crystals of a beautiful blue colour are occasionally found in the gravels of the Mogôk Ruby mines.

Beryl.

Beryl in its pale-coloured varieties is of common occurrence in the granite-pegmatites of India, but the crystals are generally too much fissured for use as gem-stones. Occasionally in the pegmatite veins which are worked for mica in Bihar and in Nellore, large crystals of beryl, many inches across, are found to include clear fragments which might be cut as aquamarines; but the only places in India where attempts have been made to excavate pegmatite solely for its aquamarines are at Padyur (Pattalai) near Kangayam, Coimbatore district, where they accompany the mineral clevelandite, at different places in the

[1] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 102 (1904).
[2] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 212 (1909).
[3] *Op. cit.*, p. 206.

Toda hills in Rajputana, and in the Skardu Tehsil of Kashmir. Stones of considerable value were obtained from the mine which was worked at Padyur in the early part of the nineteenth century: a pit some 30-40 feet in depth is still in existence, but no one seems to have taken an interest in the place since Mr. J. M. Heath held a lease in 1818. The whole area is impregnated with igneous intrusions and deserves more attention than it has so far received.

At Sagar near Sarwar in the Kishangarh State, Rajputana, aquamarines occur in mica-bearing pegmatites.

The occurrences in Kashmir have proved to be of considerable importance and a paper by Messrs. C. S. Middlemiss and Lala Joti Parshad has already appeared in the Records of this department.[1] The principal source of the stones is the immediate neighbourhood of Daso village, but evidence has been obtained to shew that beryls and aquamarines occur further away up the Braldu and Basha valleys and also in the Rondu neighbourhood. The gems are found in veins of coarse pegmatite traversing foliated biotite-gneiss. They do not as a rule shew great depth of colour but the tint is delicate and limpid. In 1915 3·75 cwts. of beryl of varying quality were obtained in Skardu; the total value is not known but Calcutta and Lucknow jewellers offered from one to four annas a *rati* for clear transparent crystals. In 1916 the supply increased to 4·13 cwts. In the dull state of the market for precious and semi-precious stones it was impossible to form any precise idea of the value of this yield, but it was said to be several thousands of rupees; transparent varieties fetched from 2½ to 4 annas a *rati*. In 1917 a test experiment with 20 workmen during 10 days yielded:—A-1 quality, 7,888 carats; 1st quality, small, 7,540 carats and 2nd quality, large, 10,440 carats; the total value being close on £300. The deposits have as yet been only superficially opened up, and a long life for these mines is anticipated. During the past quinquennium the only outputs reported are 20 lbs. in 1920 and 55 lbs. in 1921.

Chrysoberyl.

Platy crystals of chrysoberyl have been found in the corundum-bearing felspar-veins near Kangayam in the Coimbatore district, associated with nepheline syenites, but the crystals are too highly flawed to be suitable for gems. Yellow crystals, transparent and of good quality, are said

[1] *Rec. Geol. Surv. Ind.*, Vol. XLIX, pp. 161—172.

to occur with mica and aquamarine in pegmatite veins at Govindsagar, Kishangarh State, Rajputana.

Garnet.

Garnets have been worked to some extent in India from the mica-schists of Rajmahal in Jaipur State, at Shahpura in Udaipur State, in the Sarwar district of Kishangarh State, and in the district of Ajmer-Merwara, all these localities being within a relatively small distance of each other. Returns have not been available to show the condition of the industry in the Jaipur State, but the statistics obtained in the past indicated the existence of a considerable industry in the other areas. All these mines were closed during the five years 1919-23. The Kishangarh garnets are stated to be the finest in India.

The garnets worked in India belong to the almandite variety, and have a purple colour. Stones of large size were obtained and their cutting for the market formed an important industry in Jaipur and Delhi. Garnets of small size but rich colour are very plentiful in the sands of the Travancore coast.

Garnets are also found in other parts of India, as in the Tinnevelly district, Madras,[1] which produced about 1,000 tons of garnet sand for abrasive purposes in 1914; the workings, however, were closed down the following year, and have remained so ever since. The only production of garnet recorded during the quinquennium under review is 407·4 cwts. in 1920, 95 cwts. in 1921 and 55·8 cwts. in 1923 from Hyderabad State; the stones were collected at Khammamet in the Warangal district and exported to Europe. Attention may be drawn to the fact that the manganese garnet, spessartite, so characteristic of the gonditic rocks of the Central Provinces, is in America sometimes used as a gem. The Indian variety varies from a beautiful bright orange to red-brown, but has not yet been found sufficiently free from flaws to be of use as a gem.[2]

Hyalite.

An output of 12·5 cwts. of hyalite, a colourless variety of opal, valued at Rs. 5,282, was reported from Katha in Burma.

Iolite.

Cordierite or iolite, a mineral exhibiting striking pleochroism, is found in the gem gravels of Ceylon, and cut as a gem under the name of lynx-sapphire and water-sapphire. A polished and roughly engraved piece of iolite found in some excavations at Budh Gaya, and showing strong

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 234 (1906).
[2] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 604 (1909).

pleochroism, deep violet to nearly colourless, has long been in the Indian Museum but no locality for the mineral was known.[1] It has now been found at two localities, namely, in complex rocks composed of sillimanite, hypersthene and biotite, in the Vizagapatam Hill-tracts,[2] and in the Kadavur Zemindari, Trichinopoly district, Madras, where Mr. P. N. Bose reports its occurrence in abundance near Udaiyapatti and Kiranur associated with labradorite and mica-schist. There are ancient pits dug apparently for this mineral.

Kyanite.

Kyanite is found at many localities in the Archæan formations of India and is occasionally used as a gem-stone on account of the fine blue colour it sometimes displays.[3] An authenticated locality for gem kyanite is Narnaul, Patiala State. The jewellers at Patiala call t *bruj*, and us.d to say that it sold at Rs. 3 to Rs. 5 per *tola*, a rate equivalent to 10*s*. to 16*s*. 8*d*. per ounce.[4] Kyanite is also plentiful in Kanaur and Bashahr in the Punjab Himalayas[5] where it has often been mistaken for sapphire.

Rhodonite.

Rhodonite, a manganese-pyroxene, is used abroad (*e.g.*, in the Urals) as a gem, and cut into all kinds of ornamental objects. It is found at many localities in India associated with manganese-ore deposits, and although none of it has yet been used for ornamental purposes, suitable material for the manufacture of small objects could be obtained at several of the mines.[6]

Tourmaline.

The beautiful red tourmaline known as rubellite is worked on a small scale in the Ruby Mines district of Upper Burma. The production during the four years 1904 to 1907 averaged 101 lbs. valued at £750. Since then no figures have been received.

An interesting report was published in 1908 by Mr. E. C. S. George, Deputy Commissioner of the district,[7] on the work'ngs for tourmaline round the small Palaung hamlet of Sanka about a mile east of Maingnin, where operations were carried on by the Chinese,

[1] V. Ball, *Proc. As. Soc. Beng.*, 1881, p. 89.
[2] T. L. Walker, *Rec. Geol. Surv. Ind.*, XXXVI, p. 13 (1908).
[3] M. Bauer and L. J. Spencer, 'Precious Stones,' p. 415 (1904).
[4] P N. Bose, *Rec. Geol. Surv. Ind.*, XXXIII, p. 59 (1906).
[5] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 102 (1904).
[6] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, pp. 144—604 (1909).
[7] *Rec. Geol. Surv. Ind.*, XXXVI, pp. 233—238.

according to local tradition, some 150 or 200 years ago. Mr. George states that after the Chinese deserted the area, the Kachins re-opened the mines about forty years ago, but the industry was again interrupted until about 1885, when more systematic operations were commenced under Pu Seinda, who contracted to conduct all mining operations until 1895. The Möng-mit (Momeit) stone-tract was afterwards notified by Government and regular licenses were taken up in 1899. During the years 1903 to 1905 the amounts recovered from 'tourmaline licenses,' the rate being Rs. 2 per worker per month, were Rs. 2,000 (£133) to Rs. 3,000 (£200) each year; since then they must have fallen off.

The tourmaline is found in soft, decomposed granite-veins, which, being generally covered by a thick deposit of jungle-clad soil, are found rather by accident than through the guidance of any superficial indications. Isolated crystals are found occasionally lying in the red soil, and men with small means sometimes find it profitable, when they have leisure, to search through the soil-cap by digging shallow pits. *Twinlons* or vertical shafts, about 4 to 5 feet square, are also put down on the chance of striking a tourmaline-bearing vein, or *kyaw*, and the owners of these *twinlons* are permitted to extend their workings underground to a radius of five fathoms from the centre of each shaft. Some of the workings extend to depths of about 100 feet, which appears to be about the limit of the miners' engineering skill. The tourmaline found is sorted into three classes: (1) *ahtet yay*, the best light-pink rubellite, of which there are two kinds, *hteik ti*, showing well-developed basal planes, and *be yan*, crystals terminated by rhombohedral faces, or with only a small development of the basal plane; (2) *akka*, of a darker colour, with the lower part of the crystals brown or black in colour; (3) *sinzi* or *arnyi*, all fragmentary crystals of any colour which are imperfect, or of a small size, less than about an inch. The *sinzi* is given without charge to the buyer of the lots of the two better kinds. The best kind, *ahtet yay*, may bring as much as Rs. 1,200 to Rs. 1,500 a viss (3·65 lbs.). The *myaw* system, or exposure of the veins on the hill-side by hydraulic action, has also been attempted at two localities with uncertain results: this work is limited to the Rains and is handicapped by the cost of leading the water-channels for long distances. All locally made purchases are effected by brokers, usually Shans or Shan Burmans. They in turn sell at Mandalay to purchasers for the Chinese market.

In 1909, 7 stones weighing 63·8 *ratis* or 37·5 carats,[1] valued at £26, were found in the Northern Shan States.

A beautiful green tourmaline with a crystalline limestone matrix is worked in a small way at Namon near the Salween river in the Southern Shan States. Green and blue varieties occur in the pegmatites of some parts of the mica-mining area of the Hazaribagh district, but the stones are not worth the cost of extraction.

Green tourmalines are also found at the Sapphire Mines area of Zanskar in Kashmir.

Zircon.

The mineral zircon is known in various parts of India, and where it occurs in the nepheline-syenite series near Kangayam in the Coimbatore district, it is picked up in small quantities and passed into the market as corundum; but it is nowhere found sufficiently transparent and flawless to be used as a gem. Similar material is met with in Travancore (see page 378).

Glass-making materials.

[H. C. JONES.]

The choice of raw materials for glass manufacture is a matter of great importance, as the quality of the finished product depends very largely on the purity of the raw materials used. The chief raw materials usually required for glass-making are silica and alkalies. Small quantities of other substances such as lime, lead oxide, etc., are required in some cases.

The ordinary impure sand of the rivers and the efflorescent alkali salt known as *reh*, so common in many parts of India, are used in various places for the manufacture of the inferior varieties of glass used for bangles.

For a long time the chief difficulty in the way of manufacturing the better grades of glass in India was the absence of known deposits of quartz-sand of the requisite purity and of suitable texture. In recent years, however, sand of great purity has been obtained from the Vindhyan sandstones at Loghra and Borgarh near Naini in the United Provinces, and from Cretaceous and Tertiary sandstones found at Pedhamli and Sankheda in Baroda State[2]; specimens of

[1] At 1 *rati* = 1¾ grains troy = ·592 carat.

[2] V. S Sambasiva Iyer: Sketch of the Mineral Resources of Baroda (1910).

these sands have been examined by Professor P. G. H. Boswell, who has reported very favourably on them; the Naini material was found to contain 98·95 per cent. SiO_2,[1] and a Baroda specimen as much as 99·39 per cent. A very pure sandstone is also found in Bikanir State. Glass-works using local sands or sandstones have been established in many parts of India, amongst which may be mentioned Allahabad, Ambala, Jubbulpore and Madras. Bombay works, however, import their sand from Naini, a distance of over 900 miles. Other materials required in large quantities, such as fire-clay, fire-bricks or coal, are to be had in various parts of India. Soda is found only in small quantities in the Central Provinces and Sind. The efflorescence known as *reh* contains a variable amount of sodium carbonate, but no experiments have yet been made to ascertain to what extent its extraction might be practicable; for the present soda must be imported.

The restriction of imports during the war gave a remarkable impetus to the Indian glass-making industry, and by the end of the last quinquennium there were about twenty factories at work. Some of these factories brought practically all their raw material hundreds of miles by rail, their sand perhaps nine hundred miles, their fire-clay and fire-bricks seven hundred and their coal at least five hundred. The late Sir Henry Hayden remarked in the last Quinquennial review that "It is difficult to see how enterprises established on such lines can hope to compete against imported glass and until the question has been more carefully studied in its technical and its commercial aspects, little progress is likely to result."[2]

Most of these glass-works established during the war, have now had to close down, as they were established without sufficient attention being paid to the various economic factors which go to make the works a commercial success in ordinary circumstances.

The refractory materials used for the furnaces and pots also play a very important part in the economic working of a glass, works. Not only is there the cost of replacement, but also the loss occasioned by the stoppage whilst the furnace is being repaired. The quality of the refractory materials may also have an effect on the quality of the glass produced. The roof and upper parts

[1] "British Resources of Sands and Rocks used in glass-making (1918)." In the footnote on page 157 it is stated that Jubbulpore sand is used in the Allahabad glass works; there is some slight confusion here, as the Allahabad works use the Loghra and Borgarn (Naini) sand, which is quarried more than 200 miles from Jubbulpore.

[2] *Rec. Geol. Surv. Ind.*, Vol. LII, pp. 294, 295.

of furnaces are usually built of silica brick, whilst the lower parts are made of fire-clay.

The value of imports of glass and glass-ware during the years 1919-23 is shown in the following table. These figures show a large increase over the previous periods. The average value for the period 1914-18 was Rs. 1,30,80,795 while that for the period 1919-23 rose to Rs. 2,46,92,330.

Value of Imports of Glass and Glass-ware.

	Rs.
1919	1,61,13,740
1920	3,36,22,890
1921	2,40,00,569
1922	2,44,32,491
1923	2,52,91,959
Average	2,46,92,330

Gypsum.

[E. H. PASCOE.]

Gypsum occurs in considerable abundance in various parts of India, occurring both in the fibrous form and as clear selenite crystals. In Baluchistan, the Tertiary clays and shales of all ages, whenever they are but slightly disturbed, contain numerous crystals of gypsum scattered throughout their mass[1]; in Sind it occurs in beds sometimes 3 to 4 feet thick near the top of the Gaj beds of the Khirthar range; in Kachh it occurs in abundance in the rocks below the Nummulitic limestones; in the Salt Range it occurs in large masses with the salt marl which lies underneath Cambrian beds but is probably of Tertiary age; along the foot of the Kala Chitta range in the Rawalpindi and Attock districts, it is characteristic of the Upper Nummulitic stage, reaching thicknesses of two or three feet locally.[2] This mineral is especially characteristic of the Lower Tertiary of north-western India, and is plentiful in the Pegu beds of Burma in the transparent form of selenite.[3]

A very interesting and, judging of the returns, comparatively important occurrence is N.N.W. of Nagaur in Jodhpur (Marwar),

[1] E. Vredenburg, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 209 (1909).
[2] Pascoe, *Mem. Geol. Sur. Ind.*, XL, 375 (1920).
[3] *Ibid.*, 216 (1912).

TABLE 115.—*Production of Gypsum in India during 1919 to 1923.*

—	1919.		1920.		1921.		1922.		1923.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.
Kashmir	..	..	..	..	187	(*a*)	73·5	(*a*)	88	(*a*)
Punjab— Jhelum	4,719	*10,705*	7,378	*17,218*	5,329	*4,663*	7,801	*6,825*	5,197	*4,547*
Rajputana— Bikanir	14,326	*12,030*	16,173	*13,122*	16,285	*13,204*	28,371	*45,154*	28,929	*57,121*
Jaisalmer	..	..	..	..	..	..	55	*400*	83	*500*
Marwar	9,273	*5,957*	10,000	*6,592*	12,000	*5,000*	4,400	*12,000*	5,000	*12,000*
TOTAL	**28,318**	*28,692*	**33,551**	*36,932*	**33,801**	*22,867*	**40,700·5**	*64,379*	**39,297**	*74,168*
Total value in Sterling	..	*£2,495* (£1= Rs. 11·5)	..	*£3,693* (£1= Rs. 10)	..	*£1,524* (£1= Rs. 15)	..	*£4,292* (£1= Rs. 15)	..	*£4,945* (£1= Rs. 15)

(*a*) Value not available.

Rajputana, where a bed, 5 feet thick or more, occurs in silt probably formed in an old salt-lake. The output from the Nagaur district during the five years 1919 to 1923 was a little less than it was during the previous period, and is shown in Table 115. The increase in the value during the last two years was a result of increased cost of extraction, due to labour difficulties, combined with an improved demand.

Selenite crystals of similar origin to the deposit of Nagaur have been recently found in the *kankar* near the base of the silt in the Sambhar lake. A small gypsum deposit of no economic value occurs in the Chamba Valley, Dholpur State.[1] There is also a considerable production of gypsum at Jamsar in Bikanir, Rajputana (see table 115).

Thick beds of gypsum are said to occur in the Kangra Chhu in Bhutan,[2] in association with dolomites. The mineral is also known in limited quantities in the Older Alluvium, in the Hamirpur district, United Provinces,[3] and under similar circumstances in the adjoining parts of the Jhansi district,[4] where it is called *usraith.* Gypsum is also found in Spiti and Kanaur, in the Punjab Himalayas. Between the Lipak and Yuland rivers in Kanaur the gypsum occurs in immense masses and thick beds replacing Carboniferous limestone; it is used locally for whitewash, but the inaccessibility of the deposits would render abortive any attempt to mine the mineral for transmission to the Indian markets.[5]

? Kyanite (see also Sillimanite).

[E. H. PASCOE.]

Early in 1921 some curious float boulders from the Lopsa Hill area of Singhbhum were brought to the notice of Mr. P. Bosworth Smith to whom we are indebted for the information which follows. On examining the specimens it was found that though the optical properties were those of kyanite the specific gravity, 3·7, was well

[1] A. M. Heron, *Rec. Geol. Surv. Ind.*, XLIV, p. 20 (1914).
[2] G. E. Pilgrim, *Rec. Geol. Surv. Ind.*, XXXIV, p 28 (1906).
[3] T. D. LaTouche, *Rec. Geol. Surv. Ind.*, XXXVII, pp. 281—285 (1909).
[4] C. A. Silberrad, *Rec. Geol. Surv. Ind.*, XLII, p. 56 (1912)
[5] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 101 (1904).

above that recorded for that mineral. Analyses of two varieties of the rock were made and gave the following results :—

	I.	II.
Silica (SiO_2)	36·80	36·20
Alumina (Al_2O_3)	62·93	63·36
Ferric oxide (Fe_2O_3)	0·12	0·12
Lime (CaO)	0·16	0·04
Magnesia (MgO)	..	0·08
	99·91	99·80

The analyses sh w that the rock is a remarkably pure form of one of the mineral f rms of silicate of alumina which theoretically should contain 36·8 r cent. of silica and 63·2 per cent. of alumina.

Experiments were made on a series of samples of the same quality of rock represented by the above analyses and these shewed that, when the material was heated to 1300° C. and over, it increased in volume 22 per cent. It is considered that this expansion is due to the change of the structure of the aluminium silicate from kyanite forms to sillimanite forms. This change of structure and accompanying expansion on firing form a most valuable asset in what may be termed a "super-refractory," and experiments are being made both in England and America to take advantage of this property of various kyanite rocks. Several hundreds of tons have been sent from Singhbhum to England and it is considered probable that a large demand may arise for the material to be used in the manufacture of steel crucibles, glass pots, gas retorts as well as of bricks and blocks for furnace linings.

Kyanite rocks of varying degrees of purity are found bordering the Singhbhum copper belt, mostly to the north and east (the hanging-wall side) of the copper occurrences. The rocks are noticeably green, grey and white in colour, comprising quartzites, quartz-mica-schists and granulites with, in places, a very pure form of light coloured mica schist, the mica being an alumina one. Mr. Bosworth Smith has examined this band of quartz-alumina rocks at many points from Lopsa Hill on the north-west to Badia on the south-east and beyond, and has found in it lenticular masses of kyanite rock varying from masses of a few ounces up to large tor-like hills containing many thousands of tons of the mineral. Tests and analyses from various parts of this quartz-alumina band seem to prove that the purer deposits of the massive silicate of aluminium occur in the north-west portions of the Singhbhum copper belt.

Tests made on the rock from the Khasi Hills referred to under "Sillimanite" (*Rec. Geol. Surv. Ind.*, LV, 1923, p. 26) show that this is similar to and has the same refractory qualities as some of the Singhbhum kyanite rocks.

Marble.[1]

[E. H. PASCOE.]

Occurrence.

India has long been famous for its marbles, chiefly on account of the fine buildings, such as the Taj Mahal, built from this material by the Moghals. Amongst the remains recently found on the ancient site of Mohen-jo-Daro in the Larkana district of Sind were shaped and dressed blocks of polished marble, many of them evidently for building purposes. The stone resembles that from Mekrana in Rajputana, whence we may imagine it to have been carried across the desert to the ancient city. Associated with these shaped blocks were found seals bearing a script having many resemblances to the Sumerian script of Mesopotamia. The marble quarries of north-western India, therefore, appear to have an antiquity which it would be difficult to rival. The best known occurrences of white marble are at Mekrana in Jodhpur, Kharwa in Ajmer, Maundla in Jaipur, Dadikur in Alwar, and Tonkra in Kishangarh, the last-named being dolomitic marble. It is to the coarseness of their grain that these marbles owe in part their resistance to the weather; it is their purity that enables them to maintain their white surface, and it is their translucence that gives them their delicate softness, which could never be obtained from a fine-grained marble more suitable for statuary than for architectural purposes. Similar white marble occurs in unlimited quantities forming the hills of Kyaukse, Sagyin, and Mandalay, on the banks of the Irrawadi. A coarse white marble is found in Mergui; whilst a saccharoidal dolomitic marble is exposed in large quantities at the far-famed Marble Rocks, forming a beautiful gorge traversed by the Narbada river near Jubbulpore. Marble has in the past been quarried in the Betul district of the Central Provinces.

[1] T. H. Holland, *Journal of the Queen Victoria Indian Memorial Fund*, No. II, March 1904, pp. 18—26. *See also* General Report for 1913, *Rec. Geol. Surv. Ind.*, XLIV, p. 16 (1914).

Homogeneous yellow marble, and also yellow and grey shell marble, are found at Jaisalmer in Rajputana. Serpentinous limestones, showing green and yellow tints, are found in Ajmer and other places along the Aravalli belt; but the most striking example of this class occurs at Motipura in the Baroda State in the form of a handsome mottled green marble; a beautiful marble is obtained also at Sandara. A black marble taking a good polish, and other varieties, are found in Rewa Kantha, Rajpipla. Near the Narbada River in the Indore State a fine coralline limestone, capable of a high polish, is quarried, and used in the construction of temples and palaces. Very variegated serpentinous limestones occur also in parts of the Cuddapah and Karnul formations in the Madras Presidency, and at several localities in the Nagpur and Chhindwara districts in the Central Provinces. Marble is plentiful in the Idar State. Pink marbles occur in abundance in the Aravalli belt of Rajputana, and in the Narsinghpur district of the Central Provinces. Mottled and streaked grey marbles occur in Jodhpur; dark-grey marbles are obtainable in Kishangarh and Jodhpur, while black marble has been found at Bhainslana in Jaipur. A mottled concretionary dolomitic marble occurs in the Vindhyan series in the Gwalior State, whilst onyx marbles are found at Nurpur in the Shahpur district, and near Jhuli in the Baluchistan desert.

Victoria Memorial.

Extensive tests made in the Laboratory of the Geological Survey on the Makrana marble[1] have shown that it is superior in many respects to the foreign marbles imported from Greece and Italy, and it was therefore decided to employ it in the construction of the Victoria Memorial in Calcutta. Messrs. Martin & Company, contractors for the building, opened up quarries at Makrana and erected derricks for bringing the stones to the surface, as well as an extensive plant for cutting and dressing. Considerable difficulty was experienced at first in getting the required quantity of suitable material, but this was eventually overcome and a large supply of marble of great beauty made available. With the exception of European supervision the work at the quarries was done entirely by indigenous labour and the local artisans were trained to turn out carving of a high degree of excellence. Messrs. Martin & Company's operations at Makrana during the previous quinquennium produced a steady output averaging 3,500 tons a year. During the past five years the

[1] *Rec. Geol. Surv. Ind.*, Vol. XLVI, pp. 276—279

TABLE 116.—*Production of Marble in India during 1919 to 1923.*

—	1919.		1920.		1921.		1922.		1923.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.
Baroda (*a*)	4	*1,180*	48	*1,000*	143	*3,000*	..	..	..	..
Kashmir	..	..	..	..	..	..	26	(*b*)	..	..
Rajputana—										
Alwar	..	..	..	..	200	(*b*)	200	*2,000*	1,175	*4,000*
Jaisalmer (*c*)	..	..	..	..	79	*550*	96	*840*	122	*1,200*
Jodhpur (Marwar)	8,229	*59,467*	7,000	*48,388*	8,710	*60,970*	3,537	*1,40,020*	3,675	*1,45,441*
TOTAL	**8,233**	*60,647*	**7,048**	*49,388*	**9,132**	*64,520*	**3,859**	*1,42,860*	**4,972**	*1,50,641*
Total value in Sterling	..	*£5,274* (£1= Rs. 11·5)	..	*£4,939* (£1= Rs. 10)	..	*£4,301* (£1= Rs. 15)	..	*£9,524* (£1= Rs. 15)	..	*£10,043* (£1= Rs. 15)

(*a*) Motipura district.
(*b*) Value not known.
(*c*) Nagarkantha pargana; worked by the State.

average annual production was 6,649 tons, but the last two years witnessed a considerable decrease due to the fact that Messrs. Martin & Company have ceased to work the stone. This marble has been quarried for centuries.

Marble is also quarried at the State Marble Works about 8 miles from Narnaul Railway Station, Patiala State, where an experimental marble plant has been installed. There is also a small annual output of marble in the Mandalay district for images and pillars, but no figures of production are available.

Imports.

In spite, however, of the existence of such large supplies of marbles of every variety in different parts of the Indian Empire, there is a large import of marble from abroad, chiefly from Italy and Greece. This is due partly to the great distances that separate the Indian marble deposits from such cities as Calcutta and Bombay, and partly to the systematic organisation of quarrying operations in Europe, by which the cost of foreign marble has been reduced. The foreign imports of "stone and marble" during the five years 1919 to 1923 averaged 6,625 tons a year, valued at Rs. 7,74,939; the average annual value of the exports of "stone and marble" was Rs. 1,22,776. On account of the freight advantages attaching to the supply of European marbles, it would probably not pay to lay out much capital on Indian marble quarries; but, with an order sufficiently large to warrant systematic quarrying operations, marble ought to be procurable at a cost that would repay its employment locally in Rajputana, and possibly in Burma. The Rajputana quarries are both protected and hampered by their distance from the sea-board, but in Burma there are hills of marble standing on the banks of the Irrawadi, and therefore well suited for water transport.

Mineral Paints.

[E. H. Pascoe.]

Up to the present the manufacture of mineral paints appears to be very small in proportion to the demand and the natural resources in apparently suitable minerals. In the Jubbulpore district the soft hæmatites of Jauli have been worked for red ochre, and yellow ochre has been worked in Panna State. The war gave a considerable impetus to indigenous paints, and works were set up in Mysore.

Table 117.—*Production of Ochre in India during 1919 to 1923.*

	1919.		1920.		1921.		1922.		1923.		Average.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.
Bihar and Orissa	281·3	*18,807*	400	*20,000*	450	*12,600*	400	*10,400*	441	*11,078*	394·5	*14,577*
Burma	4·6	*855*	..	..	..	..	..	..	..	..	0·9	*171*
Central India	1,512	*8,304*	1,001·4	*10,307*	3,877(*a*)	*15,200*	4,769·9	*35,730*	4,483·6	*35,609*	3,128·8	*21,029*
Central Provinces	12	*3*	..	..	221(*b*)	*126*	697	*5,139*	2,449	*8,495*	675·8	*2,753*
Gwalior	436	*1,433*	1,082	*1,900*	1,014·7	*2,180*	832	*5,720*	895	(c)*6,265*	851·9	*3,499*
Kashmir	..	..	..	..	..	..	0·5	*7*	..	..	..	..
Madras	250	*1,500*	100	*600*	..	..	..	..	435	*5,400*	157	*1,500*
Mysore	208	*5,096*	52	*624*	250	*2,500*	..	..	..	..	102	*1,644*
Rajputana(*d*)	..	..	..	..	..	..	2	*90*	2	*75*	0·8	*33*
TOTAL	**2,703·9**	*35,998*	**2,635·4**	*33,431*	**5,812·7**	*32,606*	**6,701·4**	*57,086*	**8,705·6**	*66,922*	**5,311·7**	*45,206*
Total value in Sterling.	..	*£3,130* (£1= Rs 11·5)	..	*£3,343* (£1= Rs. 10)	..	*£2,174* (£1= Rs. 15)	..	*£3,805* (£1= Rs. 15)	..	*£4,461* (£1= Rs. 15)	..	..

(*a*) Ochre (weight not reported) valued at Rs. 1,014 from Kothi and 2,000 tons of ochre (value not reported) from Bundelkhand not included.

(*b*) 60 tons of ochre (value not reported) from Chanda not included.

(*c*) Estimated

(*d*) The amount of ochre produced in the Jaipur State during 1919-23 amounted to an average of 311 tons.

Such figures as are available are summarized in Table 117, in which the values are mostly much understated, being usually the rental or royalty paid. The Central Indian production is derived mainly from Panna and Sohawal; the mines in the former State are being worked at present by Messrs. The Olpherts Paints and Products, Limited, and by Messrs. Turner Morrison and Company, both of Calcutta. The production in the Central Provinces is due mainly to the operations of the mines in the Jubbulpore districts.

Gwalior was separated from the Central India Agency in 1920; the statistics relating to that state have therefore been shown separately in Table 117. The mines in this State are worked by the Paints and Mineral Products Company, Limited. There was a small output of ochre in Bihar and Orissa from the Singhbhum and Puri districts.

Ochres, red, yellow, and of other colours, are commonly used by Indians in many parts of the country, in a crude or simply levigated form, under the generic name *geru*. A common source of supply is laterite in the Peninsula and Burma, but well-defined ochres occur in deposits of various geological ages down to the Archæan hæmatites. In the Trichinopoly district yellow ochre is obtained from the Cretaceous rocks, and in Burma deposits are known among the Tertiary beds of the Myingyan district. It is also probable that various grades of ochre, umber, and sienna could be set aside from the 'country' when working the Vizagapatam manganese-ore deposits. A black slate near Kishangarh has been successfully tried on the Rajputana-Malwa Railway.

Mineral Waters.

[W. A. K. CHRISTIE.]

One curious feature in connection with Indian minerals is the neglect of our numerous hot and mineral springs. To what extent the value of these is purely fanciful is a matter of small concern for the time being; for whether they have the medicinal properties claimed for them or not, there is no doubt that well-advertised mineral waters have an economic value, and numerous varieties from Europe and Japan are scattered over India, and brought to the continual notice of the travelling public in all the railway refreshment rooms. The indigenous inhabitants have for many ages recognised a value in mineral waters and in the hot springs, which are

often charged with more than usual quantities of mineral matter. In many cases these, like most unusual natural phenomena, have become sacred to the Hindus, and have consequently become places of resort for pilgrims from great distances. Of instances of this sort may be mentioned the occurrences at Manikarn in Kulu where the pilgrims cook their rice in the hot springs emerging in the shingle beds close to the ice-cold stream of the Parbati river. The hot water is also led into the neighbouring temple and rest-house for baths, being supposed to be of value for rheumatism. At Lasundra in the Kaira district, and at Vajrabai in the Thana district, Bombay Presidency, springs of sulphurous water, having a temperature of 115° F., are also resorted to by Hindu pilgrims. Generally it may be said that hot springs, often sulphurous, are common throughout the Tertiary areas of Sind and Baluchistan on one side, and of Assam and Burma on the other side of India, the distribution being similar (and perhaps dependent on similar causes) to the distribution of petroleum, with its constant associates of salt and gypsum. Other springs occur along the foot-hills of the Himalaya, in the Kharakhpur hills, etc., sufficiently well distributed to permit of easy transport. The springs at Jawalamukhi in the Kangra district contain bromide and iodide of sodium and potassium; the water is said to be a remedy for goitre. The provincial gazetteers contain sufficient references to these springs to guide private enterprise, but more might be done in the way of analysis of the waters, which would be as interesting from a scientific as possibly from an economic point of view. The mineral water of Sitakund in the Kharakhpur hills is the only one which has been turned to account; this has some reputation in Bengal as a table water. An investigation into the radio-activity of the thermal springs of the Bombay and Madras Presidencies was undertaken by the Reverend Dr. A. Steichen and the Reverend H. Sierp, of St. Xavier's College, Bombay. The results of these two observers were published in two papers in the Indian Medical Gazette, Vols. XLVI and XLVII (December 1911 and December 1912). The springs at Tuwa on the line from Cambay to Godhra (Panch Mahals) were found to possess unusually high radio-active properties. Comparatively large emanations were found at Vajrabai and Unei also. The authors express the opinion that more should be made of the therapeutic properties of these and other radium-containing springs.

Dr. L. L. Fermor, in his "Mineral Resources of Bihar and Orissa" (*Rec. Geol. Surv. Ind.*, LIII, 290, 1921) has discussed the geological mode of occurrence of the springs of that province as a guide to geological enquiry and to those who may wish to turn some of them to commercial account.

A bibliography of the hot springs of India and of those which are reputed to possess some medicinal value or are charged with mineral matter will be found in an Annotated Index of Minerals of Economic Value by T. H. D. LaTouche, Geological Survey of India (Calcutta, 1918).

Nickel.

[E. H. Pascoe.]

Ores of nickel (nickeliferous pyrrhotite) have been found amongst the copper-ores of Khetri and other places in Rajputana. Nickel has also been detected in small quantities in chalcopyrite and pyrrhotite found associated with the gold-quartz reefs of Kolar, and in pyrite said to be from the Henzada district of Burma.

Complex sulphide ores, consisting of pyrrhotite, pyrite, chalcopyrite, and molybdenite, have been received from the Tovala taluk in South Travancore. Both nickel and cobalt are present in quantities beyond mere traces, but nothing is yet known as to the extent of the deposits, nor have any proper average samples been assayed. A surface sample of ore showed 1·20 per cent. of copper, 0·64 per cent. of nickel, and 0·08 per cent. of cobalt, with 12 grains per ton of gold and 2 dwts. 12 grs. per ton of silver. Further investigations may show that the deposits are richer than is indicated by this analysis.

On the 1st August 1907, the issue to the public was commenced of the new 1-anna nickel coinage, consisting of an alloy of 25 parts of nickel with 75 of copper, leading to a further consumption of nickel. The consumption of nickel in India in the form of German-silver, has increased still further during the past five years owing to the introduction of the 2-anna and 4-anna pieces: an 8-anna piece of the same alloy was put into circulation but has been withdrawn. The imports of nickel received at the Bombay Mint in 1919-20 and 1920-21 totalled 2,784 tons, 10 cwts., 3 qrs., 22 lbs., 15 oz., valued at Rs. 85,74,038; those at the Calcutta Mint amounted to 1,128 tons, 17 cwts., 1 qr., 8 lbs., valued at Rs. 34,65,234. No nickel was imported during the years 1921-22, 1922-23 and 1923-24.

Phosphates.

[H. C. JONES.]

The late Sir H. H. Hayden remarked that "a regrettable feature in connection with Indian mineral resources is the absence, in a country where agriculture is such a predominant industry, of any phosphatic deposits of proved value, and a further circumstance to be regretted is the export of phosphates in the form of bones. Bone meal and other animal manures are now manufactured to a certain extent in Calcutta, but until a supply of cheap sulphuric acid is available superphosphate cannot be made, and the small quantity used is imported from Europe." During the past five years the value of the materials imported under the head of manures has varied considerably. In 1919-20 the value of manures imported was much the same as just before the war, but in the year 1921-22 the quantity and value fell exceedingly from 4,873 tons valued at Rs. 12,99,660 to 959 tons valued at Rs, 1,56,006. The following year saw a considerable rise both in quantity and value, which was again increased in the last year under review. The export of bones which had also fallen excessively during the war, and amounted to 17,000 tons in 1918-19, rose to over the pre-war figure in 1919-20, amounting to 83,693 tons. It has increased somewhat during the remainder of the period and the average for the five years was 90,422 tons; the exports of all manures, including ammonium sulphate which had also fallen considerably in quantity during the war and amounted to 47,000 tons, rose rapidly in 1919-20 to 132,000 tons.

TABLE 118.—*Exports of Manures from India during the years 1919-20 to 1923-24.*

—	TOTAL MANURES.		ANIMAL BONES.	
	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.
1919-20	132,291	*1,47,69,260*	83,693	*75,35,130*
1920-21	115,487	*1,28,27,220*	99,148	*1,00,05,490*
1921-22	105,110	*1,16,77,419*	89,005	*92,07,750*
1922-23	110,060	*1,23,78,292*	84,571	*90,83,844*
1923-24	130,729	*1,68,88,880*	95,695	*1,14,73,820*
AVERAGE .	*118,735*	*1,35,08,214*	*90,422*	*94,61,207*

TABLE 119.—*Imports of Manures during the years 1919-20 to 1923-24.*

—	Quantity.	*Value.*
	Tons.	Rs.
1919-20	4,656	*9,61,780*
1920-21	4,873	*12,89,660*
1921-22	959	*1,56,006*
1922-23	7,983	*11,54,247*
1923-24	9,774	*13,11,622*
AVERAGE	5,649	*9,74,663*

Among the phosphatic deposits of India only two seem to merit attention, the phosphatic nodules of Southern India and the apatite-magnetite rock of Singhbhum. The first of these is the deposit of septarian nodules occurring in the Cretaceous beds of Perambalur taluk, Trichinopoly district. Dr. H. Warth estimated in 1893 that to a depth of 200 feet the beds contained nodules to the amount of 8 million tons, but the phosphates are distributed irregularly through clay, the quantity varying, in the different excavations made, between 27 and 47 lbs. per 100 cubic feet, and, in the shallow workings, 70 lbs. per 100 cubic feet. Analyses of these nodules show them to contain from 56 to 59 per cent. of phosphate of lime with about 16 per cent. of carbonate. The sparse distribution of the nodules and their high calcium carbonate content are unfavourable to the commercial success of any attempt to manufacture superphosphate. Attempts have been made to use the material in a finely powdered condition as a fertilizer, but the results have not been encouraging.

Phosphatic nodules of Trichinopoly.

The existence of apatite-magnetite rocks at Patharghara and Musaboni in Dhalbhum has been known for some years, and deposits have been located along a belt stretching for 12 miles in a direction S. 37° E. from Patharghara to Khejurdari, and included in concessions secured by the Bengal Iron and Steel Company (now the Bengal Iron Company), for iron-ore, and by a private syndicate for apatite. The latter concession was previously worked by the Great Indian Phosphates, Limited, but this Company subsequently went into liquidation.

Magnetite-apatite deposits, Singhbhum.

The magnetite-apatite rock occurs as lenses in the Dharwar schists parallel to the strike, varying in size from 90 feet long by 24 feet thick in the middle, through lenses 2 feet or 3 feet by 1 foot, down to lenticles a few inches long, and then to separate granules and crystals disseminated in the associated schists. As a rule apatite is the predominant mineral.[1] The amount of phosphate rock available has not yet been determined, while experiments made on the crushed rock with a magnetic separator did not prove successful and work was suspended.

The production of phosphate rock (apatite) from the Sungi mine in Singhbhum amounted to 500 tons valued at Rs. 5,000 in 1919, 347 tons valued at Rs. 3,420 in 1921 and 1,082 tons valued at Rs. 10,820 in 1923. The production of phosphate rock from the Nandup area in Singhbhum was 1,340 tons valued at Rs. 17,000 in 1922 and 3,680 tons valued at Rs. 70,000 in 1923.

Rare Minerals.

[E. H. PASCOE.]

The minerals of the so-called rare earths are derived chiefly from the pegmatites of peninsular India. None of those referred to below, with the possible exception of molybdenite in Tavoy and possibly of ilmenite in Travancore, is known to occur in quantities sufficient to justify extensive exploitation.

Molybdenite, the sulphide of molybdenum, occurs in Tavoy as—

(*a*) an accessory mineral in the granite,
(*b*) in greisens bordering cassiterite and wolfram veins,
(*c*) in quartz veins with cassiterite and wolfram,
(*d*) in pegmatites with wolfram, cassiterite and sometimes scheelite,
(*e*) in veins with sulphides and entire exclusion of cassiterite and wolfram.

The mineral is widely distributed but of more frequent occurrence in or about veins in granite than in those enclosed by sedimentary rocks. It is especially abundant in the Wagon region Kyaukanya and at Sonsin which furnishes the only known occurrence of type (*e*). No attempts have been made, in spite of the

[1] *Rec. Geol. Surv. Ind.*, L. p. 14.

high value of the mineral, to recover it by scientific processes, and, owing to its flakiness, it is not recoverable by the primitive processes of "cobbing and panning" so prevalent in the field. The small quantities which have been exported were obtained by laboriously picking out the larger flakes by hand from the quartz matrix. The Sonsin deposit is the most promising known at present but it is little more than a "prospect." Molybdenite was one of the first minerals to form in the Tavoy veins and is often found intergrown with mica on the walls.

Molybdenite occurs in the crystalline rocks and in quartz in various parts of Chota Nagpur. It has been found as scattered scales in pegmatites intruded into the Khondalite series near Kunaveram village in the Upper Godavari Agency, Madras. A similar mode of occurrence has also been noticed in the aplite and pegmatite veins traversing the schistose gneisses 1½ miles east of Karadikuttam in Retiambadi Mitta, west of Palni, Madura district, Madras. It occurs in an elæolite-sodalite-cancrinite pegmatite at Mandaoria, near Kishangarh, Rajputana, and has been found in a pegmatite cut through at a depth of 2,500 feet in the Balaghat lode, Ooregum, Kolar Gold Field, Mysore. Molybdenite occurs disseminated through the pyrrhotites of the Travancore State.

From Tavoy a total output of 7·5 cwts. valued at Rs. 1,407 was reported during the period 1919-1923, obtained in the course of wolfram mining operations. Queensland and New South Wales produce most of the world's supply.

Platinum and Iridosmine.—Platinum and Iridosmine have been found in the auriferous gravels of the rivers draining the slopes of the Patkoi ranges, both on the Burma and the Assam sides. The former metal used to be obtained, with gold, by the Burma Gold Dredging Company from the gravels of the Irrawadi above Myitkyina. This Company went into liquidation in 1918 and since that time no platinum has been produced in India. The output from 1914 amounted to a little over 67 ounces valued at £378.

Columbite-Tantalite.—There is a perfect gradation from columbite (niobate of iron and manganese) to tantalite (tantalate of the same metals) due to the gradual replacement of niobium (or columbium) by tantalum. This change is accompanied by a corresponding increase in specific gravity, the range being from 5·3 to 7·3. There is at present no commercial use for niobium (columbium), but

tantalum is used in the preparation of metallic filaments for lamps; consequently tantalite is of much greater value than columbite, the value depending on the percentage of tantalic oxide in the mineral.

Although at any locality where one of these minerals occurs, the presence of the other may reasonably be expected, tantalite is a very rare mineral. Columbite is frequently found in the mica-bearing pegmatites. It is not uncommon in the Singar Zamindari, Gaya district, where beautiful crystals have been obtained near the village of Pichhli[1]; in the Kodarma forest, Hazaribagh district and Monghyr (Pananoa Hill) in the Province of Bihar and Orissa; in the Madura, Nellore, Salem and Trichinopoly districts of the Madras Presidency; at Masti[2] in the Bangalore district and other places in the Mysore State[3]; in Kashmir, near Machial, 20 miles from the Padar Sapphire Mines.

Tantalite occurs with columbite at Pananoa Hill near Jhajha Railway Station, East Indian Railway. Two specimens sent to the Geological Survey Office have the high specific gravities of 6·75 and 6·92; assays have shown 37 and 52 per cent. of $Ta_2 O_5$ respectively.

Ilmenite, titaniferous iron ore, occurs as a common accessory mineral in many of the crystalline rocks of peninsular India. It is occasionally found in masses of some size in the mica pegmatites of Bihar and Orissa. It accompanies wolfram at Degana in Rajputana. It is found in abundance in the beach sands of Travancore which yielded 400 tons valued at £1,200 in 1922, and 700 tons valued at £2,100 in 1923. Ilmenite is plentiful in concentrates from Tavoy and other parts of Burma. About 3 miles south of Kishangarh in Rajputana large crystals of ilmenite, 2-3 inches in diameter, are found associated with clear calcite crystals forming a broad vein in the granitoid gneiss. This ore was at one time smelted in the local native furnaces.

Rutile, one of the natural forms of titanic oxide, is widely distributed throughout many of the crystalline schists. It has been found in pieces of some size during exploratory work for mica in the neighbourhood of Ghatasher in the Narnaul district of Patiala State, Punjab.[4] Mr. Bose also reports the occurrence of this mineral in the vicinity of Kadavur in the Trichinopoly district of Madras.

[1] G. H. Tipper; *Rec. Geol. Surv. Ind.,* L, pp. 260 and 261 (1919).
[2] *Rec. Mysore Geol. Dept.,* III, p. 182 (1900-01).
[3] Mineral Resources of Mysore, p. 192.
[4] P. N. Bose; *Rec. Geol. Surv. Ind.,* XXXIII, p. 59 (1906).

The two minerals, ilmenite and rutile, have attracted additional attention during the past few years as being sources for titanium pigments. Titanium oxide produces a white paint of twice the covering power of White Lead. Indian bauxite contains a high percentage of titanium, and whenever an aluminium industry is established in India, especially if the Bayer process be used, a new source of titania will be available in the by-product slimes.

Sphene, titanite and silicate of calcium, is a not uncommon accessory mineral in many of the crystalline rocks. A large and beautiful crystal of a variety containing a noticeable percentage of cerium earths was obtained by Dr. A. M. Heron in Rajputana, but its exact provenance is unknown.

Pitch-blende.—Pitch-blende or uraninite with other uranium minerals has been found at two localities in the Singar Zamindari, Gaya district, Bihar and Orissa. The occurrence at Abraki Pahar near the village of Bhanen Kap has been known for some years.[1] The chief mineral associated with the pitch-blende here is triplite, a phosphate of iron and manganese, in considerable quantities. Columbite and zircon also occur. The locality was visited by the late Mr. R. C. Burton, who found that the pitch-blende occurs as nodules in the pegmatite, each nodule having an aureole of yellow uranium ochre.[2] A company was formed for the exploitation of this occurrence but it was liquidated in 1914. The prospecting work done did not show the presence of any large deposit. The second locality is near the village of Pichhli where the pitch-blende is found in a pegmatite in a similar way to the above. The associated minerals are monazite, apatite and columbite.[3]

Green and yellow incrustations containing uranium occur on the apatite-magnetite rock at Sungri, Dhalbhum, Bihar and Orissa.

Samarskite.—The very rare mineral samarskite has been found in a mica-bearing pegmatite near Gridalur village,. Nellore district, Madras.[4] Altogether $2\frac{1}{2}$ cwts., valued at Rs. 101, were won during the period under review from the Sankara mica mine of this district. Samarskite is a very complex niobate and tantalate, chiefly of uranium, the yttrium earths, and iron. Some pieces of a black mineral supposed to be samarskite have been found in pegmatites

[1] T. H. Holland, *Mem. Geol. Surv. Ind.*, XXXIV, p. 31 (1901).
[2] R. C. Burton, *Rec. Geol. Surv. Ind.*, XLIV, p. 31 (1914).
[3] G. H. Tipper, *Rec. Geol. Surv. Ind.*, L, pp. 259—261 (1919).
[4] G. H. Tipper, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 342 (1910).

in the Bangalore district, Mysore State. A small piece of samarskite has recently been received from Tavoy.

Sipylite, a niobate of erbium and other rare earths occurs in association with samarskite. It has also been found in a mica pegmatite about 3 miles to the north-west of Śankara, Nellore district.

Hatchettolite, a tantalo-niobate of uranium, has been identified from the Tavala taluq Travancore. Associated with this is found a closely allied mineral, as yet unidentified. A specimen similar to the latter has been discovered in a pegmatite 5 miles west of Vaiyampatti, Kadavur Zamindari, Trichinopoly district, Madras.

Æschynite, a titano-niobate of the cerium earths, has been identified from a pegmatite in the Eraniel taluq, Travancore State.

Gadolinite, a silicate of yttrium, beryllium and iron, has been found in a tourmaline pegmatite, associated with cassiterite, in the Palanpur State, Bombay Presidency.

Allanite, a hydrous silicate of calcium, aluminium, iron and the rare earths, has been found in some of the pegmatites of the Nellore district (Sankara, Vadlapudi and Turpupundla) and near Palni, Madura district, Madras. In Bihar and Orissa it occurs near Bahea village, in the Ranchi district.

Zircon, orthosilicate of zirconium, is a common accessory mineral in many granites and gneisses, and as such it is often found accompanying gravels and sands derived from such rocks. It is a constant constituent of the beach sands of Travancore which produced 160 tons valued at £1,280 in 1922, and 145 tons valued at £1,160 in 1923. Fine crystals are to be obtained from some of the pegmatites of the Travancore State. Zircon is found in the nepheline syenites near Kangayam, Coimbatore district; in pegmatites at Kadavur, Trichinopoly district; and in the Seitur graphite mine, Ramnad, Madras Presidency. Large clusters of crystals of a dark brown colour have been obtained from Abraki Pahar, Gaya district, Bihar and Orissa. A hydrated form resembling cyrtolite containing a small percentage of uranium is associated with samarskite in the Nellore district, Madras.

A mineral related to *Xenotime*, orthophosphate of the yttrium earths, has recently been noticed in long rhombic prisms associated with the phosphate deposit at Kanyaluka in Dhalbhum.

Slate.

[L. L. Fermor.]

Slate-quarrying gives a means of livelihood to numbers of workers along the outer Himalayas, where the foliated rocks, though often not true clay-slates, possess an even and perfect fissility, which enables them to be split for slabs and even fine roofing slates at Kanyara. In the Kangra district, at Kanyara, work is being carried on in a systematic manner by the Kangra Valley Slate Company, Limited, which, during the five years ending the 30th June 1923, has declared dividends of 22 per cent. per annum. The same company work quarries in clay-slates amongst the Aravalli series near Rewari in the Gurgaon district south of Delhi. There are in addition several smaller companies working slate in the Kangra and Gurgaon districts.

In the Kharakhpur Hills, Monghyr district, Bihar, the properties held by Messrs. C. T. Ambler & Company were transferred to a limited company, Ambler's Slate and Stone Company, in 1913. During the period under review this company raised on an average 2,825 tons of slate annually, valued at Rs. 45,073. The slate worked is often slightly phyllitic and is probably of Dharwarian age. Though not giving the thinnest varieties of roofing slate, these quarries produce fine slabs for which a more extended use is continually being found for flooring, roofing, ceilings, and for small dishes and curry platters for native use. Enamelled slate slabs for electrical purposes, switch-boards and fuse-bases are also manufactured. Recently a new branch of the business has been opened for the manufacture of school slates, and an average of 22,000 framed slates is being produced monthly. Some of the quarries held by this company date back to ancient times, and probably yielded the very fine piece of slate from which the throne of the Nawabs Nazim of Bengal, now shown in the Indian Museum, was fashioned.

Slate of good quality and in considerable quantity was observed in the valley of the Tuzu River, some 25 miles east of Kohima, in the Naga Hills.[2] The locality is just within the borders of our administered territory, but is somewhat remote for present-day

[1] T. H. Holland, *Rec. Geol. Surv. Ind.*, XXXI, p. 43 (1903).
[2] E. H. Pascoe, *Rec. Geol. Surv. Ind.*, XLII, p. 263.

TABLE 120.—*Production of Slate during 1919 to 1923.*

—	1919		1920		1921		1922				AVERAGE	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
Bihar and Orissa—												
Manbhum	..	..	10	*10*	..	..	..	..	..	..	(c)	(c)
Monghyr (b) . . .	3,038	*49,277*	2,978	*47,993*	2,829	*45,247*	2,624	*41,231*	2,637	*41,618*	2,820	*45,073*
Singhbhum . . .	2	*22*	..	..	..	..	41	*525*	1,688	*2,820*	(d)346	*733*
Madras—												
Karnul	..	..	..	..	213	*340*	108	*206*	113	*228*	(d)87	*155*
Mysore—												
Tumkur	..	..	..	..	1·5	(a)	12	(a)	..	..	(c)	(c)
Punjab—												
Gurdaspur . . .	84	*28*	..	..	..	..	..	..	.	..	(c)	(c)
Gurgaon	2,651	*40,367*	2,008	*33,617*	42,630	*29,812*	30,664	*20,885*	2,832	*33,543*	16,157	*31,645*
Kangra	5,323	*87,963*	5,359	*89,080*	4,878	*91,759*	4,936	*95,194*	5,087	*1,10,538*	5,117	*94,907*
Rajputana—												
Alwar	..	..	185	(a)	185	(a)	200	*1,000*	150	*2,000*	(c)	(c)
United Provinces—												
Almora	17,786	*5,377*	45,555	*5,948*	1,384	*5,851*	1,192	*6,662*	664	*4,377*	18,316	*5,643*
Garhwal	..	..	..	..	..	..	..	..	4	*1*	(c)	(c)
Naini Tal . . .	..	..	..	..	98	*84*	8	*6*	116	*65*	44	*31*
TOTAL .	**28,879**	*1,83,034*	**56,095**	*1,76,648*	**52,218 5**	*1,73,093*	**39,785**	*1.66,009*	**13,291**	*1,95,190*	**37,887**	*1,78,187*
Total value in sterling . .		*£15,916* (£1 = Rs. 11·5)		*£17,665* (£1 = Rs. 10)		*£11,540* (£1 = Rs. 15)		*£11,067* (£1 = Rs. 15)		*£13,013* (£1 = Rs. 15)		*£13,840*

(a) Value not available.
(b) Output by Ambler's Slate and Stone Co., Ltd.
(c) Not taken into average.
(d) Average of five years.

exploitation. It is used by the half-civilised local tribes for roofing, millstones and other purposes.

Slate is also being worked in various parts of the so-called transition series of rocks of the Peninsula; such figures as are available to show the extent of the trade are given in Table 120 with the figures of production of the two companies already mentioned. From these it appears that the average annual output of slate during the quinquennium has been 37,887 tons valued at Rs. 1,78,187 against 34,737 tons valued at Rs. 1,60,939 during the previous period.

Sillimanite (see also Kyanite).

[E. H. PASCOE.]

The occurrence of the mineral sillimanite in the Khasi Hills, Assam, has been demonstrated in a rather curious way. In March 1908, the Deputy Commissioner of the Khasi and Jaintia Hills reported the discovery of corundum at Nongmaweit and other places, and specimens passed through the office of the Geological Survey on their way to Austria. As the samples were very small and scanty, none of them was broken or properly examined, and the Austrian consignee, when applied to for information, merely asked for larger samples. Amongst the material subsequently despatched there must evidently have been a certain amount of corundum, a small quantity of which mineral had been observed by Mr. LaTouche, who had searched this area in 1887. A Miscellaneous Note on the occurrence was published in Vol. XXXVI, part 4, of the Records of this Department, including a remark that the "corundum extracted..........finds its way all over the hills for sale as hones." A reference was made to the presence of corundum (*mawshinrut*) at three localities in the Nongstoin State in the N. W. Khasi Hills in the Quinquennial Review of the Mineral Production for 1904-08,[1] and in subsequent mineral reviews statistics of the amount extracted and its value were published as follows :—

Khasi Hills : Assam.

1916	. . . . . .	36,540	cwt. valued at	£2,555
1917	. . . . . .	41,200	,, ,,	£3,799
1918	. . . . . .	37,920	,, ,,	£3,862
1919	. . . . . .	12,660	,, ,,	Rs. 47,475
1920	. . . . . .	3,320	,, ,,	Rs. 2,151
1921	. . . . . .	1,276	,, ,,	Rs. 826

[1] *Rec. Geol. Surv. Ind.*, Vol. XXXIX, p. 244.

The figures shew that, as an abrasive, the Khasi mineral produced a war industry. In 1921, dissatisfaction expressed by purchasers in London at the lack of hardness of a consignment, led the European Agents of the Khasia Mines Company, Messrs. Pawle and Brelick, to ask for a chemical and microscopic examination from Messrs. G. T. Holloway of Limehouse. The latter found over 35 per cent. of silica in one of the brands, which also shewed a hardness of only about 6½ instead of 9; Messrs. Holloway expressed the opinion that this sample consisted of sillimanite. Mr. C. S. Fox, Assistant Superintendent of the Geological Survey of India, attached to the Indian Trade Commissioner in London, was then consulted. He was able to confirm Messrs. Holloway's opinion that the material was mostly sillimanite and the rest a mixture in varying proportions of sillimanite and corundum. He pointed out at the same time that, as a refractory, especially for glass furnaces, sillimanite was of greater value than the abrasive corundum.

In 1922, Captain F. W. Walker was deputed to make a brief examination of the deposits at Nongmaweit. Four "*in situ*" out-crops of sillimanite were found, as well as several boulder occurrences, the latter being the chief source of supply up to the present. The home of the material seems to be a pegmatite vein or veins, but the field evidence is very slight. The country rock consists mostly of biotite gneiss and quartz granulites, the latter being found in several of the tunnels constructed. Pure sillimanite occurs in long lath-shaped crystals of a white colour, with a pearly or greasy lustre, but a massive form is commonly found. The majority of the material, however, is composed of an altering sillimanite, and has a brown or steel-grey colour. Rutile occurs as an accessory, while other associated minerals include quartz, biotite, sericite, garnet and zircon. Sections from the sillimanite rock shew it to be composed of lath-shaped crystals of sillimanite arranged in radiating aggregates; a fibrous variety is very common.

The mineral sillimanite is a widely distributed one, but is found usually in small quantities only. It is known in Germany, France, Scotland, South Africa, Brazil, the United States, Burma and Ceylon. It is impossible to estimate the total quantity available in Assam until the loose "float" material has been removed, but the amount of the latter alone is of the order of 3,000 tons.

Sodium Compounds.

[W. A. K. Christie.]

Besides sodium chloride, other salts of soda, notably the sulphate (*khari*) and carbonate (*sajji*), accumulate in the soil of areas where the climate is dry, giving rise to the alkaline efflorescence known as *reh*, which renders large areas quite sterile. Both the sulphate and carbonate are also prominent amongst the sodium compounds in the brine of the Rajputana Salt Lakes. Carbonate of soda occurs in quantity in the water of the Lonar Lake and in the lakes of Eastern Sind referred to below.

Imports.

There was formerly a considerable production of both salts for consumption in India, but the native material has been largely displaced by the cheap supplies of chemically manufactured material obtained from Europe. The total imports of soda salts increased very rapidly up to 1918, since when they have been fairly constant; in 1905 they were estimated at £70,000, in 1913 at £212,649, in 1918 at £651,885; from 1919 to 1923 they averaged £656,553. The imports of sodium bicarbonate during the quinquennial period averaged 100,170 cwts., valued at Rs. 9,45,821, whilst the imports of caustic soda averaged 92,618 cwts., valued at Rs. 17,29,127. The annual total imports of soda salts averaged 895,325 cwts., valued at Rs. 86,11,171.

The Magadi Soda Company, which went into liquidation shortly after the close of the period covered by this review, has an up-to-date plant at Budge-Budge near Calcutta for the manufacture of caustic soda from sodium carbonate imported from Magadi in Kenya Colony, where huge natural deposits of remarkable purity occur. The product made commands as good a price as the imported article. The heavy freight on suitable limestone is one of the factors which make it difficult for the company to compete with caustic soda from England and America.

For information concerning the alkali compounds used and manufactured in India, reference may be made to the *Agricultural Ledger*, No. 5 of 1902, published by the Reporter on Economic Products, Calcutta. Other numbers of the Ledger give information about *reh*. Those interested in *reh* lands should also consult J. W. Leather's 'Investigations on Usar Land,' Allahabad (1914), and Watson and Mukerjee's papers referred to below.

Sodium Sulphate.

Reh occurs as an efflorescence over a considerable part of Bihar and, generally speaking, is a mixture of sodium carbonate (*sajji matti*), sodium sulphate, (*khari*) and common salt. Usually the carbonate predominates but in many parts of Bihar the sulphate is the chief constituent. The methods of extraction used are very similar to those pursued in the manufacture of crude saltpetre. Returns of production are available for three districts, Saran, Champaran and Muzaffarpur, and are given in the table below.

TABLE 121.—*Production of Sulphate of Soda in Bihar and Orissa during 1919-20 to 1922-23.*

	CHAMPARAN.		MUZAFFARPUR.		SARAN.		TOTAL.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
1919-20 . .	2,010	*54,675*	5,086	*1,54,660*	7,564	*2,05,740*	15,260	*4,15,075*
1920-21 . .	357	*9,720*	2,496	*67,900*	2,351	*63,945*	5,204	*1,41,565*
1921-22 . .	228	*6,195*	1,688	*45,920*	1,572	*42,750*	3,488	*94,865*
1922-23 . .	564	*15,345*	3,118	*84,820*	2,865	*77,940*	6,547	*1,78,105*
Average . .	*790*	*21,484*	*3,247*	*88,325*	*3,588*	*97,594*	*7,625*	*2,07,403*

Lonar Lake.

The proposal to utilise the accumulations of soda salts in the Lonar Lake (19° 59′ : 76° 33′) in the Buldana district, Berar, has been frequently raised, but the place is too inaccessible at present for anything like development on a large commercial scale. This lake was investigated by T. H. D. LaTouche and the writer.[1] The lake lies in a depression in the Deccan Trap, and its origin, though not satisfactorily explained, has been regarded as probably similar to that of the so-called 'explosion craters' of the kind described by R. D. Oldham in the Lower Chindwin district.[2] LaTouche, however, regards it as due to the collapse of a gigantic blister caused by vapour or molten rock. The depression is nearly circular, about a mile in diameter and 300 feet deep; at the botton there is a shallow lake of saline water, which is variable in density and quantity according

[1] *Rec. Geol. Surv. Ind.*, XLI, pp. 266—285 (1912).
[2] *Rec. Geol. Surv. Ind.*, XXXIV, p. 137 (1906).

to the season of the year. The most prominent salts in solution are the carbonate and chloride of sodium, the former being in excess and often found separated on account of supersaturation, when it takes the mineralogical form of *trona* or *urao*, $Na_2 CO_3$, $NaHCO_3$, $2H_2O$. A series of analyses by F. J. Plymen of the various crystallised products indicate the presence of the following percentage proportions of soda salts (a small portion of the soda being replaced by potash) :—

—	*Bhuski.*	*Papri.*	*Khappal.*	*Dalla.*	*Dalla Nimak.*	*Nimak Dalla.*
Na_2CO_3 . .	32·72	23·19	24·09	46·90	33·05	11·67
$NaHCO_3$.	27·53	17·21	18·18	33·18	26·09	8·58
NaCl . .	3·35	41·99	37·45	trace.	24·25	71·11

In each case the ratio of carbonates is very close to that required for the urao formula, and sufficient water for crystallisation is also present. The writer calculated that in March 1910 the brine contained about 2,000 metric tons of alkali reckoned as sodium carbonate, and that the superficial 1·5 metres of mud (with an alkalinity equivalent to 0·26 per cent. of sodium carbonate) contained some 4,500 tons of sodium carbonates. In the absence of borings the depth to which such mud persists is unknown. The presence of the sodium carbonate in the lake water is regarded as due to concentration by evaporation of stream waters in the absence of an exit from the lake, whilst the chloride is regarded as in part wind-borne from the sea-coast.

Considerable quantities of soda salts were recovered from this lake in the old days for use in the manufacture of soap and glass; but, since the principal markets for soda are now served by the cheaper and purer products of the European chemical manufacturer, there is little demand for the impure salts from Lonar. Suggestions are offered for improving the methods of manufacture, but even under the most favourable conditions the industry could never become an important one, owing to the limited resources of the lake. During the first four years of the quinquennium no soda

was recovered from the Lake. In 1923 the Pioneer Alkali Works, Limited, produced 600 tons, valued at Rs. 23,750.

United Provinces.

E. R. Watson and K. C. Mukerjee (*Journ. Ind. Industries and Labour*, II, 13, 1922) have investigated the efflorescent deposits in the surface soil of the United Provinces. The soluble matter is mainly sodium carbonate with subordinate amounts of sulphate and chloride. By what may be a somewhat optimistic method of exterpolation they "calculate that 7,321,000 tons of crude soda, containing 4,888,000 tons Na_2CO_3, could be obtained annually from the visibly efflorescent areas in this province." The Government of the United Provinces started a demonstration factory in 1917 for the manufacture of soda ash from the *reh* salts. After a time it was decided that it had been clearly demonstrated that the process was a commercially successful one and the factory was leased to a private firm. This firm, however, failed to develop the industry and the lease has now been cancelled and the factory closed down (*Op. cit.* 211).

Sind.

Although statistics are not available further back than 1895, Sind has yielded annually small quantities of natural soda from a remote past. The trade in alkali is mentioned by H. Pottinger writing in 1816, and is noted in the first edition of the Sind Gazetteer (1874). The product, which is *trona* either in pure form or associated with chloride and sulphate, is known as *chaniho* or *kharo chaniho*, and is both used locally and exported from Karachi.

The soda is collected during the hot weather, at the periods of maximum evaporation, from the alkaline lakes (*dhands*) of eastern Sind. These alkaline *dhands* are found exclusively in that portion which is covered with wind-blown sand, and may be classed in two geographical groups :—

(1) The Nara group, lying in a belt of country about 20 miles broad by 50 miles long, bisected by the East Nara Canal. The greater part of this belt lies in Khairpur State, but a southward extension penetrates the Nawabshah district, and the Sanghar *taluqa* of Thar and Parkar.

(2) The Jubo group, situated entirely in Khairpur, and lying to the east of Kot Jubo in the eastern part of the State.

These *dhands* were examined in 1918-19 by G. de P. Cotter whose report, "The Alkaline Lakes and the Soda Industry of Sind,"

forms volume XLVII, part 2, of the Memoirs of the Geological Survey of India.

The *dhands* are situated in depressions (*talis*) usually of an oval shape between the sand-hills (*bhits*), and are produced owing to the accumulation of percolating (*sim*) water flowing from the basal layer of the desert sand, the water being prevented from sinking further by the highly impervious alluvial clays which everywhere in the Sind desert underlie the wind-blown sand. This percolating or *sim* water carries into the *dhands* the soluble salts of the buried soil. These salts are similar in composition to the *reh* or *kalar* salts of N. W. India, and consist of carbonate, bicarbonate, sulphate, and chloride of sodium with subordinate amounts of potash salts. In the Sind desert within the limits of the alkaline areas, the carbonate and bicarbonate as a rule are preponderant, although some highly saline, and one or two sulphatic *dhands* occur.

The *dhands* may be classified as (1) *dhands* which deposit or have in former years deposited *chaniho* owing to solar evaporation and deposition in the hot weather, and (2) *dhands* which owing either to depth of water or to insufficient concentration of dissolved salts have never deposited *chaniho*. In the Khairpur State there exists a total of 94 *dhands* of the first category, 48 being situated in the Nara, and 46 in the Jubo area. These *dhands* produce *chaniho* only in favourable years, those which contain much water only producing in dry years, and those with scanty water remaining dry during the whole annual round in dry years, but producing in wet years. Some of the *dhands* are probably permanently dry owing to secular desiccation, and will never produce again. Of the 94 *dhands* listed, 30 produced *chaniho* in 1918, 40 were dry, and 24 had excessive water.

The second category consists mainly of large *dhands*, some of which are rich in alkali, and might possibly be worked for soda on a commercial basis. Thirty-three *dhands* of this class have been recorded in the Khairpur State.

In the Nawabshah district only three *dhands* produced *chaniho* in 1918: only one *dhand*—Akanwari—is of any importance. Besides this there are two large alkaline *dhands* which have never yielded. The Thar and Parkar district has not yielded *chaniho* since 1899, in which year the worked *dhands* deposited a residue consisting largely of common salt.

The waters of the two largest alkaline non-producing *dhands* in the Khairpur State have the following analysis:—

Name of Dhand.	CO_3	SO_4	Cl	Total dissolved solids.	Sp. Gr.
Pur Chandar . . .	19·75	2·73	17·57	79·88	1·070
Khariri Chachwari . .	20·68	14·57	20·59	103·4	1·089

Note.—The figures represent grammes per litre.

In most of the *dhands*, the deposit is *trona* with a purity of 90 per cent. or over. In some, such as Lambro, Chilhanwari, Bagarwaro, the deposit is contaminated with a large intermixture of sulphate; a few *dhands* such as Barko, although yielding a fairly pure alkaline deposit, are deficient in their stock of bicarbonate, and therefore yield normal carbonate largely (a dehydrated natron).

An experimental soda works was installed in 1920 by the Salt Department for the recovery of *trona* of good quality in the Nawabshah district.

The following are the total amounts of *chaniho* produced in Sind during 1917-18 to 1923-24:—

Year.	Nawabshah district.	Khairpur State.
	Tons.	Tons.
1917-18	252	4,213
1918-19	293	2,854
1919-20	(*a*)	3,338
1920-21	331	4,632
1921-22	274	4,124
1922-23	274	4,748
1923-24	274	4,906

(*a*) Not available.

TABLE 122.—*Value of exports of Chaniho from Karachi during the years 1921-22 to 1923-24.*

Year.	Aden and Dependencies.	Bombay.	Madras.	Kathiawar.	Kachh.	Persia.	Other Countries.	TOTAL.
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
1921-22 . .	43,648	33,639	25,739	23,518	2,483	2,067	2,105	133,199
1922-23 . .	54,081	86,106	15,865	27,009	2,852	2,161	3,092	192,156
1923-24 . .	55,585	41,114	20,265	21,733	2,197	1,340	5,364	147,548

There are said to be extensive deposits of soda efflorescences at several places in the southern part of the Bihar division, particularly to the south of Nawada in the Gaya district and in Shekhpura in the Monghyr district. [See The mineral Resources of Bihar and Orissa, by L. L. Fermor. *Rec. Geol. Surv. Ind.*, LIII, 301, (1921).]

Bihar.

For references to other occurrences the article "Soda" in An Annotated Index of Minerals of Economic Value by T. H. D. LaTouche (Geological Survey of India, Calcutta, 1918), should be consulted.

Steatite.

[E. H. PASCOE.]

One of the most widely distributed minerals in India is steatite, either in the form of a coarse potstone—so called on account of its general use in making pots, dishes, etc.—or in the more compact form suitable for carvings, and in its best form, suitable for the manufacture of gas-burners. Cooking utensils of steatite are much in request by high-caste Hindus, since they can be purified after use by fire and communicate no unpleasant taste to food. There is a trade of undetermined extent in nearly every province, but it is in most cases impossible to form even a rough estimate of its value. An exhaustive account of the Indian occurrences of steatite was published by Mr. F. R. Mallet in the *Records, Geological Survey of India*, Vol. XXII, part 2 (1889); and a later note[1] adds further details with regard to the deposits in the Minbu district, Burma. In 1911-12, Mr. C. S. Middlemiss[2] discovered a large deposit of steatite of very fair quality near Dev Mori in Idar State, Bombay Presidency, associated with various other magnesian minerals (actinolite, magnesite, serpentine and asbestos). He estimates that bed of steatite to be over 1 mile long with a width of over 200 feet and a vertical dip. On this basis it is calculated that 2 million tons are obtainable in the first 20 feet from the surface. Dr. A. M. Heron has collected notes on some hitherto undescribed steatite deposits in Jaipur State, Rajputana.[3] The principal localities are: Dogetha, 2½ miles N.E. of Raialo; Gisgarh; and Morra. In the last-mentioned

[1] H. H. Hayden, *Rec. Geol. Surv. Ind.*, XXIX, p. 71 (1896).
[2] *Rec. Geol. Surv. Ind.*, XLII, p. 52 (1912).
[3] *Rec. Geol Surv. Ind.*, XLIII, p. 21 (1913).

TABLE 123.—*Production of Steatite in India during 1919 to 1923.*

	1919.		1920.		1921.		1922.		1923.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
Bihar and Orissa—												
Bhagalpur	..	..	..	..	90	*900*	..	..	..	..	...	(b)
Mayurbhanj	45	*3,400*	52	*3,600*	62	*3,850*	71	*6,900*	65	*6,000*	59	*4,750*
Singhbhum	..	..	412	*(a)25,409*	27	*3,356*	0·55	*31*	76·8	*4,424*	103·7	*6,644(c)*
Burma—												
Pakokku Hill Tracts	..	..	0·4	*105*	1·5	*270*	3·05	*585*	3·1	*600*	1·6	*312(c)*
Central India—												
Bijawar	..	..	..	..	..	..	0·6	*94*	0·4	*64*	...	..(b)
Central Provinces—												
Jubbulpore	1,452	*27.539*	2,295·5	*43,342*	1,080	*19,699*	89·8	*1,852*	999	*9,249*	1,183·3	*20,336*
Madras—												
Bellary	..	..	3	*15*	..	..	..	..	..	..	..	.. (b)
Karnul	4	*662*	..	..	..	..	..	..	..	..	...	...(b)
Nellore	74	*4,762*	32	*2,864*	40·5	*5,866*	70·4	*3,969*	77	*4,417*	58·8	*4,376*
Salem	450·6	*15.990*	538·5	*14.650*	528	*13,987*	542·6	*14,298*	890·2	*20,947*	590·0	*15,974*
Mysore	10	*163*	265	*5,300*	138	*414*	93·5	*935*	108	*960*	122·9	*1,554*
United Provinces—												
Hamirpur	95	*12,150*	73	*10,069*	98	*13,200*	27	*7,425*	34	*2,500*	65·4	9,069
Jhansi	4	*320*	10	*600*	5	*240*	8	*400*	4	*192*	6 2	330
Rajputana (Jaipur State)	4,672	*32,672*	177	*1,701*	5,979	*49,495*	3,847	*26,162*	4,706	*32,205*	3,888·2	*26,509*
TOTAL	6,807	*97.058*	3,853·4	*1,07,555*	8,049 0	*1,02,187*	4,753·50	*62,651*	7,023·5	*81,558*	6,079·1	*89,854*
Total value in sterling		*£8,440* (£1 = Rs. 11 5)		*£10,755* (£1 = Rs. 10)		*£6.812* (£1 = Rs. 15)		*£4 177* (£1 = Rs. 15)		*£5,437* (£1 = Rs. 15)		

(*a*) Includes the value of 12,348 plates, the weight of which is not available. (*b*) Not taken into average. (*c*) Average of five years.

area one of the beds measures 25 feet in thickness, and pockets of steatite extend over a distance of 5 miles.

Such figures as are available for the output of Indian steatite are summarised in Table 123. The values assigned to the mineral vary between very wide limits, and although this is no doubt partly due to differences in the value of the product according to the use to which it is put, yet some of the figures are probably but rough estimates.

The steatite deposits on the north side of the Marble Rocks in the Jubbulpore district form pockets in the dolomite of the gorge. They were formerly worked by native methods with a small annual production, but have since been taken up on mining lease by Messrs. P. C. Dutt and by Messrs. Burn & Company; the latter have erected a grinding mill in their pottery works at Jubbulpore and are converting their steatite into powder, whilst deposits at Gowari and Lalpur on the south side of the Narbada have been secured by the Bombay Mining and Prospecting Syndicate. The annual output from this area during the period averages 1,183 tons valued at Rs. 20.336, about three-quarters of what it was during the previous five years.

The Burmese production comes from the Pakokku Hill Tracts and was used for pencils. In former years steatite was also produced in the Minbu and Myitkyina districts. The mines in the Minbu district have been described by Sir Henry Hayden[1] and are situated some 30 miles west of Hpa-aing. The veins of the mineral are very inconstant and ramify through dark green serpentine, expanding occasionally to 8 or 9 inches across. The colour is green and the quality good. The absence of production is said to be due partly to the gradual replacement of the steatite pencil by pen and paper, and partly to the exhaustion of the deposits.

Mr. A. Ghose opened up the steatite deposits at Muddavaram and Musila Cheruvu near Betamcherla in the Karnul district, and took out a mining lease in 1912. A market was obtained in America and on 158 tons exported in 1913, the prices obtained ranged from £7 for 'nugget' steatite to £14 per ton for block steatite, c.i.f. New York or European ports, most of the output of that year being white steatite from Musila Cheruvu. The larger portion of the steatite of this locality is green, and has fetched a price of £10 a ton. At Muddavaram the steatite is ivory white associated with quartzose rock and magnesite and is suitable for

[1] *Rec. Geol. Surv. Ind.*, XXIX, pp. 71—76.

small articles, such as gas-burners. The output in 1914, however, fell to 210 tons, in 1915 to *nil* and in 1916, 1917 and 1918 to just over 10 tons each year; during the period under review it has all but ceased.

Sulphur, Sulphuric Acid and Soluble Sulphates.

[L. L. FERMOR.]

Small quantities of sulphur are obtainable on the dying volcano of Barren Island in the Bay of Bengal, in the State of Kalat in Eastern Baluchistan, and on the Koh-i-Sultan and neighbouring volcanoes in Seistan and Eastern Persia. The Kalat sulphur mine near Sanni, which was formerly worked to some extent, has recently been examined and the available sulphur estimated at 10,000 tons;[1] this is a conservative estimate, but even if the actual amount is several times greater, the deposit cannot be regarded as of serious potential value, since it represents little more than a year's supply.

India is likely, therefore, to be ultimately dependent for her acid on by-products from the reduction of metallic sulphides, and in the previous review it was reported that a scheme was on foot for the erection of a plant at Jamshedpur to treat the zinc concentrates of Bawdwin. The projected initial capacity of the plant was some 30,000 tons annually, but as a cheap supply of acid would be the key to many industries, there is no doubt that a very much larger output would be readily absorbed. The absence of such industries was seriously felt during the war. Thus the average annual value of imported bleaching materials alone during the five years 1914-18 was £88,709; for this import formerly brought from Europe, India was dependent on Japan, and complaint was made of the quality of some of the manufactured articles supplied by that country. With a local supply of acid this would not have occurred. The abandonment of the project referred to above has, however, unfortunately pushed into the future the possibility of any considerable advance towards making India self-contained in the matter of the more essential chemical manufactures.

A considerable amount of acid is already manufactured in India, but the industry is dependent entirely on imported sulphur. This

[1] G. de P. Cotter, *Rec. Geol. Surv. Ind.*, L. p. 137 (1919).

used formerly to come from Sicily, but from 1917-18 to 1919-20 most of India's imports were derived from Japan. In 1920-21 Italy began to regain her former place. Her most serious rival now is the United States of America.

The imports of sulphur during the five years 1919 to 1923 are shown in Table 124 and averaged 8,469 tons annually, valued at Rs. 14,35,853, as compared with an annual average of 7,801 tons valued at Rs. 11,12,055 for the period of the previous review.

TABLE 124. *Imports into India of Sulphur, Sulphuric Acid, Ammonium Sulphate, Ammonia and Salts thereof, during the years 1919 to 1923.*

YEAR.	Sulphur.	Sulphuric acid.	Sulphate of ammonia.	Ammonia and salts thereof.
	Tons.	Tons.	Tons.	Tons.
1919	5,522	42	..	919
1920	10,871	477	..	1,061
1921	6,559	229	13	396
1922	9,157	151	16	866
1923	10,235	13	850	878
TOTAL	42,344	912	879	4,120
Average	*8,469*	*182*	*176*	*824*

The average annual import of sulphuric acid was 182 tons valued at Rs. 1,15,905 as compared with 396 tons valued at Rs. 1,14,585 during the quinquennium 1914 to 1918, and 3,188 tons valued at Rs. 5,86,305 during the quinquennium 1909 to 1913. This decrease in imports of sulphuric acid is due to the increasing production of this chemical at numerous plants in India.

The acid as manufactured at different plants varies in strength from 65 to 95 per cent. H_2SO_4, according to the purposes for which the acid is required. The data of production available have

accordingly been reduced to the uniform basis of 100 per cent. acid, and are summarised in Table 125.

TABLE 125.—*Production of Sulphuric Acid in India during the years 1919 to 1923.*

(Statute tons in terms of 100 per cent. acid.)

—	1919.	1920.	1921.	1922.	1923.	Totals 1919-23.
Bengal	2,995	2,785	2,506	2,290	3,760	14,336
Bihar and Orissa	2,111	2,514	2,543	2,498	6,065	15,731
Bombay	2,296	2,036	2,046	2,051	1,563	9,992
Burma	2,850	2,594	3,064	3,268	3,928	15,704
Madras	967	1,293	812	738	1,003	4,813
Punjab	37	55	102	77	178	449
United Provinces	630	630	630	630	630	3,150
TOTAL	11,886	11,907	11,703	11,552	17,127	64,175

From this table it will be seen that during the first four years of the period the annual production was a little under 12,000 tons, but that in 1923 the production jumped to 17,127 tons of 100 per cent. acid. This jump was mainly due to the increased recovery of by-product ammonia as ammonium sulphate at the coking plants, iron and steel works, and collieries in the provinces of Bengal and Bihar and Orissa. The production of sulphuric acid in Bihar and Orissa is in fact mainly for this purpose, as will be seen from the fact that the total ammonium sulphate produced in this province during the quinquennium contained a minimum of 12,693 tons[1] of acid out of a total production of 15,731 tons, whilst Bengal consumed for this purpose a minimum of 3,423 tons [1] of acid out of a production of 14,336 tons.

[1] Assuming no loss of acid in the process.

The producers of sulphuric acid are as follows, the figures in brackets being the total production of acid at 100 per cent. during the period under review :—

Bengal—

D. Waldie & Co., Konnagar (7,713 tons).

Bengal Iron Co., Kulti (3,682 tons).

Bengal Chemical and Pharmaceutical Works, Calcutta (2,941 tons).

Bihar and Orissa—

Tata Iron & Steel Co., Jamshedpur (7,777 tons).

Barakar Coal Co., Loyabad (3,220 tons).

East India Railway Colliery, Giridih (2,563 tons).

Bararee Coke Co., Ltd., Jamadoba (1,126 tons).

Bararee Sulphuric Acid Plant (1,103 tons).

Jharia Sulphuric Acid Co., Lodna (313 tons).

Burma—

Burma Chemical Industries, Rangoon (15,704 tons).

Bombay—

Eastern Chemical Co. (8,994 tons).

Dharamsi Morarji & Co. (998 tons).

Madras—

Parry & Co. (3,332 tons).

Cordite Factory, Nilgiri Hills (1,481 tons).

Punjab—

Several small producers (449 tons).

United Provinces—

D. Waldie & Co., Cawnpore (2,905 tons).

Sulphuric Acid Manufacturing Co., Ghaziabad (245 tons).

This wide distribution of sulphuric-acid manufacturing plant throughout India is a healthy sign of growing activity in chemical industries in the country, though, as might be expected, the objects of manufacture are very varied. Thus all the producers in Bihar and Orissa, and the Bengal Iron Company in Bengal, manufacture acid for their own ammonia by-product recovery plants; the Burma Chemical Industries manufacture chiefly for the refining of petroleum products in the Burmese oil industry; and the Nilgiri Cordite

Factory produces for the manufacture of explosives. All the other producers may be taken as manufacturing for general chemical purposes.

The statistics of production of ammonium sulphate are given in Table 126, from which it will be seen that India produced 21,707 tons during the quinquennium.

TABLE 126.—*Production of Sulphate of Ammonia in India during the years 1919 to 1923.*

——	1919.	1920.	1921.	1922.	1923.	TOTAL.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Bengal	1,137	963	644	298	1,569	4,611
Bihar and Orissa . .	3,299	2,769	2,568	2,636	5,824	17,096
TOTAL .	4,436	3,732	3,212	2,934	7,393	21,707

The principal producers were as follows, the figures in brackets being the total production in tons during the quinquennium :-

Bengal—

Bengal Iron Co. (3,911 tons).
Oriental Gas Co. (700 tons).

Bihar and Orissa—

Tata Iron and Steel Co. (9,776 tons).
Barakar Coal Co. (3,483 tons).
East Indian Railway Colliery, Giridih (2,179 tons).
Bararee Coke Co. (753 tons).
Jharia Sulphuric Acid Co. (676 tons).
Indian Iron & Steel Co. (221 tons).

Ammonium sulphate is, of course, a valuable fertiliser for certain crops, and the production recorded above should, therefore, prove of value to Indian agriculture. Unfortunately, however, the larger

proportion of the Indian production is exported, mainly to Ceylon and Java.

TABLE 127.—*Exports of Ammonium Sulphate from India during the years 1919 to 1923.*

YEAR.	Quantity in tons.
1919	3,964
1920	5,890
1921	3,256
1922	2,439
1923	2,819
TOTAL	18,368
Annual average	*3,674*

Against these exports are to be set off only the small average annual imports of 176 tons, leaving the net annual loss to India of 3,498 tons of a valuable nitrogenous fertiliser. To a slight extent this loss is counter-balanced by occasional imports of calcium cyanamide (including nitrolim) during the period, the imports of nitrolim according to Messrs. Shaw Wallace & Company, Calcutta, being as follows:—

	Tons.
1919	1,000
1920	1,500
1921	*Nil*
1922	*Nil*
1923	200

Reference may also be made here to the recorded imports of ammonia and salts thereof summarised in Table 124, giving an annual average of 824 tons, and utilised for general industrial purposes.

Sulphate of iron and copper.

For many years the pyritous deposits in India have been turned to account for the manufacture of soluble sulphates of iron and copper. The case of alum has been referred to already (*supra*, page 296),

and with the alum, which was formerly obtained in quantity from the decomposed pyritous shales at Khetri and Singhani in Rajputana, copperas and blue vitriol were also obtained. No statistics are, however, available with regard to the history of these industries, which have had to give way to the importation of cheap chemicals from Europe, the imports of alum and copperas being considerable.

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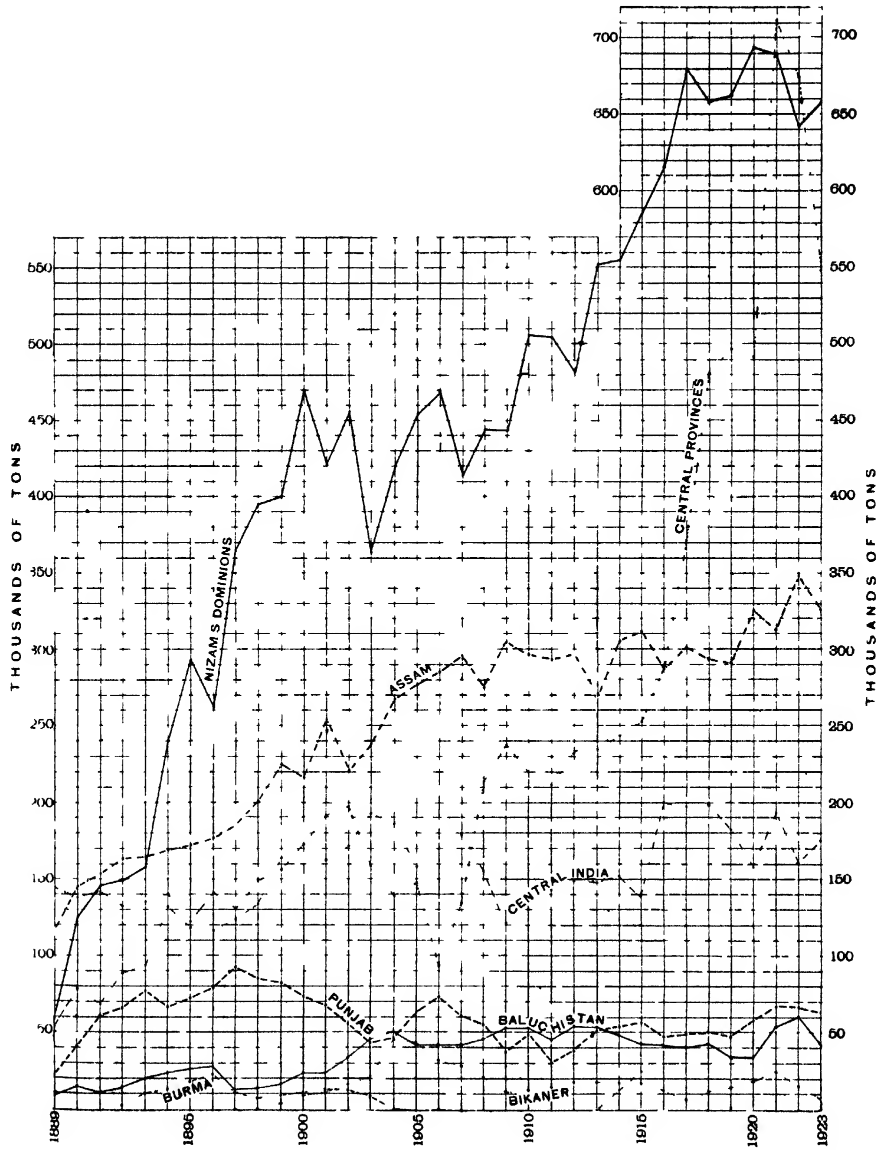
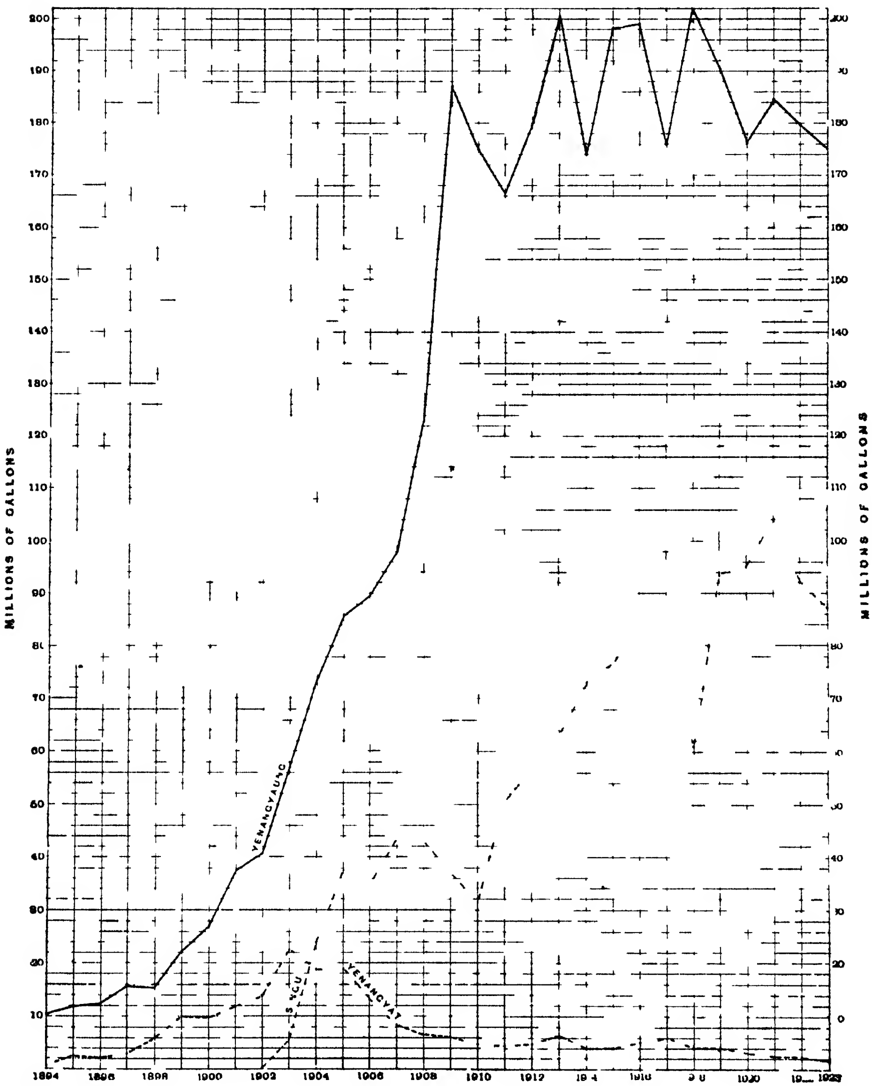


G S I Calcutta.

PROVINCIAL OUTPUT OF COAL FOR THE YEARS 1889-1923, EXCLUDING BENGAL, BIHAR AND ORISSA

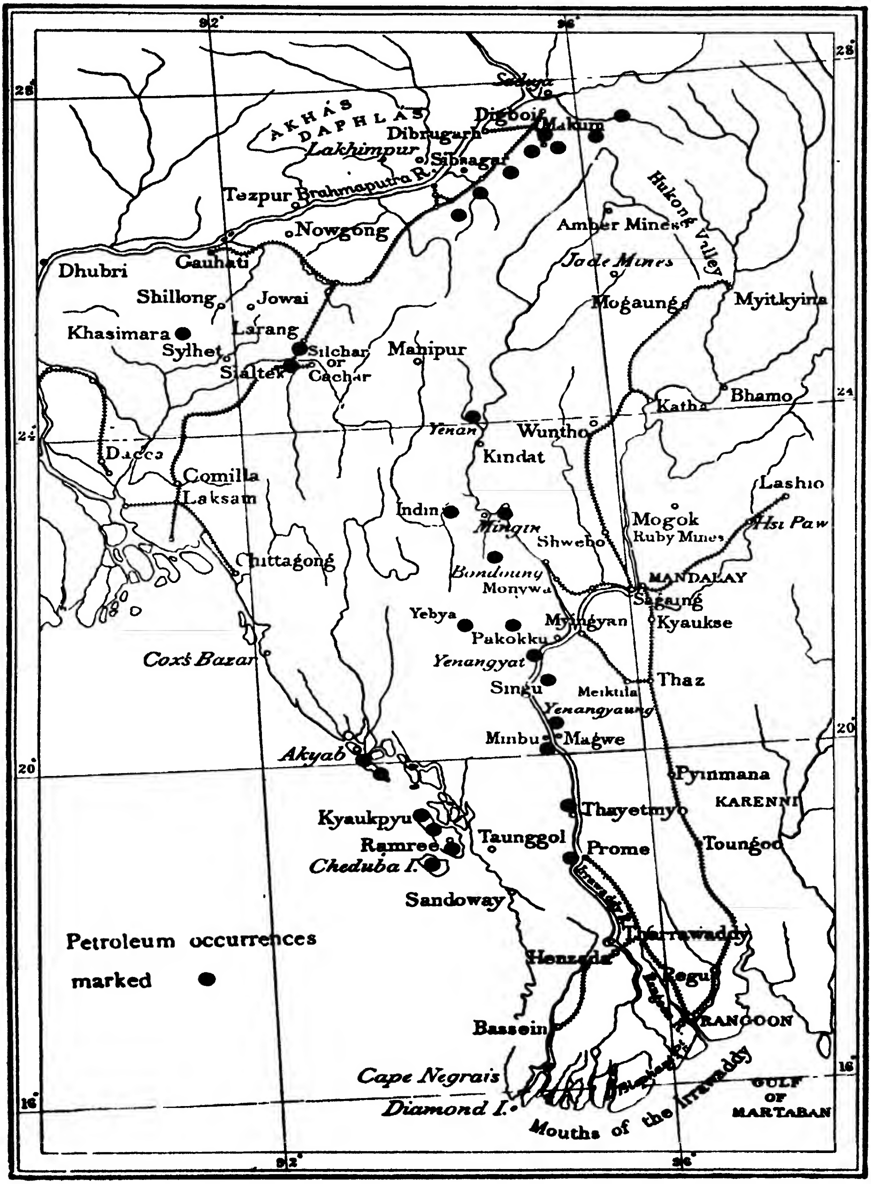
Records, Vol LVII, Pl. 3.



PRODUCTION OF UPPER BURMA OIL-FIELDS

G S I Calcutta

Records, Vol. LVII, Pl. 4.



G. S. I. Calcutta.

OCCURRENCES OF PETROLEUM IN ASSAM AND BURMA.

(Scale 1 inch = 128 miles.)